VOLUME 64 WINTER 1961 NUMBER 4

THE BRYOLOGIST

Quarterly Journal of the American Bryological Society

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THE BRYOLOGIST.—A quarterly journal devoted to the study of North American mosses, hepatics, and lichens, published by the American Bryological Society. **Subscription price, in the United States, $5.00 per year, net; in all other countries, $5.15.**

Back volumes of THE BRYOLOGIST are available from Dr. Lewis E. Anderson, Department of Botany, Duke University, Durham, N. C.; or the Secretary-Treasurer, at the following prices: volumes 1-4, $1.25 each; volumes 5-36, $2.50 each (60 cents per individual number); volume 37, $3.00; volumes 38-45, $3.50 each (85 cents per individual number); volumes 46-49, $4.00 each; volume 50, $8.00; volumes 51-56, $6.00 each ($2.00 per individual number).

PUBLICATION OFFICE: Seeman Printery, Durham, N. C.

Address manuscripts to the Editor:

DR. HOWARD A. CRUM, National Museum of Canada, Ottawa, Ontario, Canada.

Manuscripts should be typewritten, double-spaced, on 8½ by 11 inch sheets. Only first copies (not carbons) should be submitted. Reprints of articles will be supplied at a reasonable price if ordered when corrected galley proof is returned.

Address subscriptions, applications for membership, and advertisements to the Secretary-Treasurer, DR. WILLIAM A. WEBER, University of Colorado, Boulder, Colo.

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Entered as second-class matter at the Post Office at Durham, N. C.

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THE BRYOLOGIST

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THE AMERICAN BRYOLOGICAL SOCIETY

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CHROMOSOME STUDIES ON SOME MOSSES OF THE SOUTHEASTERN UNITED STATES[1]

MATTI AL-AISH[2] and LEWIS E. ANDERSON[3]

Sufficient knowledge of chromosome numbers and chromosome behavior has now accumulated so that a beginning can be made in taxonomic correlations in mosses at family, generic, and specific levels. The junior author during the last several years has undertaken, with the aid of a number of co-workers, a cytological survey of the mosses of North America, especially of eastern North America. The objectives of the survey are to determine the chromosome number and to observe chromosome behavior in as many species as possible. Ultimately it is hoped that chromosome counts and information concerning chromosome behavior can be appropriately related to taxonomy, geography, ecology, morphology, and biology of the various taxa. Observations concerning anomolous chromosome behavior should be of basic cytological interest. The present paper is a continuation of several papers that have dealt with species from the southern United States (Anderson & Bryan, 1958a; Al-Aish & Anderson, 1960a, b, c, d) and supplement Bryan's rewarding studies on cytotaxonomy (1955, 1956a, b, 1957) of mosses from the Southeast.

Chromosome studies were made on spore mother cells at meiosis. Living plants with developing sporophytes were collected

[1] Grateful acknowledgment is made to the National Science Foundation for a grant of research funds to Duke University (NSF-G9610), which has made the present study possible. We are much indebted to Dr. Richard T. Forman and Dr. Harold Robinson for their aid in the collection of living material.

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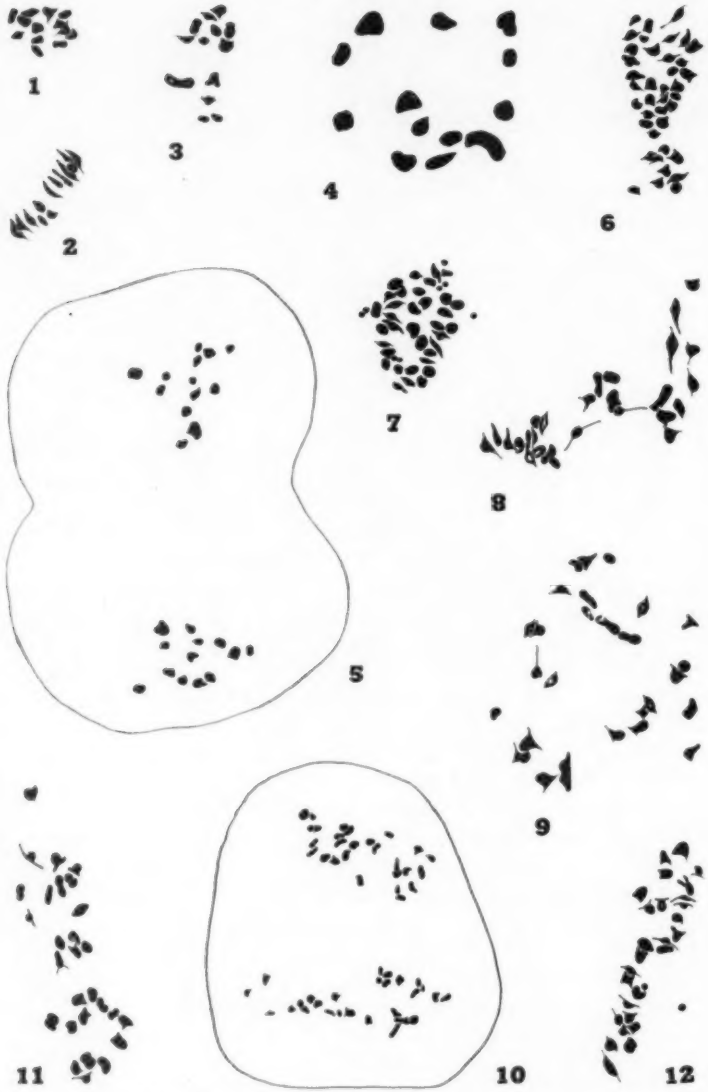

FIG. 1-2. *Ditrichum pallidum* (Hedw.) Hampe, $n = 13$. 1. Polar view of MI showing 13 bivalents. 2. Side view of MI; note uniformity of disjunction. FIG. 3-5. *Weissia controversa* Hedw., $n = 13$. 3. Side view of early MI in a population from Durham County. 4. Polar view of MI from an Orange County population. Note the larger size of chromosomes

and either studied immediately, or the plants were placed in a refrigerator at a temperature of about 2° C., according to the methods described by Anderson and Crum (1959). The cytological techniques employed were essentially the same as outlined by Steere, Anderson, and Bryan (1954). In most instances heat was omitted during the preparation of slides, a procedure which apparently tends to reduce stickiness and clumping of chromosomes.

Voucher specimens from each of the populations studied have been deposited in the herbarium of Duke University. The results will be described and discussed under the heading of each species.

DITRICHACEAE

Ditrichum pallidum (Hedw.) Hampe
$n = 13$; *fig.* 1-2

Bryan (1956b) first studied the chromosomes of this widespread eastern species. She reported the number, $n = 26$, based on a single population from the Coastal Plain of North Carolina. Five additional populations from North Carolina, one from the Coastal Plain, three from the Piedmont, and one from the Mountains, were later studied by Anderson and Bryan (1958b), and the number, $n = 26$, was found in all five populations. The present population is the first in which the number, $n = 13$, has been found, thus establishing the existence of chromosome races.

The meiotic chromosomes stain brilliantly with aceto-orcein and are spread well apart at MI. Figure 1 shows a polar view of the chromosomes at MI. The chromosomes are remarkably uniform in size. Unlike most mosses, the complement of *D. pallidum* does not include either a pair of diminutive or m-chromosomes or an outstandingly large pair of chromosomes. No precociously disjoining pairs were observed (*fig.* 2), and lagging chromosomes are absent. No meiotic irregularities were noticed, which agrees with previous observations on the tetraploid populations (Bryan, 1956b; Anderson & Bryan, 1958b) in this and other families of mosses.

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as compared with fig. 3. The large chromosome is at 5 o'clock. 5. Polar view of anaphase I, from plants from Orange County. The large bivalent is among the last to disjoin. FIG. 6-7. *Desmatodon plinthobius* Sull. & Lesq., $n = 39$. 6. Polar view of MI. 7. Polar view of MI showing 35 bivalents and eight half-bivalents in the anaphase stage. FIG. 8-10. *Physcomitrium pyriforme* (Hedw.) Brid., $n = 27$. 8. Side view of MI showing 27 bivalents; note the thread-like extended ends of the chromosomes. 9. Polar view of MI. 10. Polar view of anaphase I with 27 half-bivalents near each pole. FIG. 11-12. *Funaria serrata* Brid., $n = 28$. 11. Side view of MI showing 28 bivalents. 12. Side view of MI showing 27 bivalents and two half-bivalents that have precociously disjoined.

In 1936, Grout described a segregate species, *D. currituckí*, which differs from *D. pallidum* only in such quantitative characters as smaller gametophytic plants, narrower and shorter leaves with a proportionately broader costa that fills more of the lamina, fewer stereid cells above the costa as shown by a cross-section, a darker, more reddish seta, a shorter capsule which is less furrowed and less sulcate, and shorter, less twisted peristome teeth with a higher basal membrane. Considerable overlapping of characters between the two species soon became apparent as additional collections were made, and the taxonomic status of *D. currituckí* became doubtful almost from the outset. Bryan (1956a), however, found the chromosome number, $n = 26$, in a single population of *D. pallidum*, while two populations of *D. currituckí* each had the number, $n = 13$. Later, Anderson and Bryan (1958b) counted the chromosomes in three additional populations of *D. currituckí*, all of which were found to have plants with a haploid number of 13. Two of these populations possessed characters that in the sense of Grout (1936) could easily have been referred to *D. pallidum*. However, after growing a transplanted population of *D. currituckí* in the greenhouse under uniform conditions and finding that the *currituckí*-like characters persisted, Anderson and Bryan concluded that *D. currituckí* is probably a valid species and so retained it in their taxonomic treatment of the autoicous species of *Ditrichum* subg. DITRICHUM in North America.

The discovery now of a diploid race of *D. pallidum* with a chromosome complement similar to that of *D. currituckí* once more raises serious doubts as to the taxonomic validity of the latter. Recently, Crum and Anderson (unpublished) examined a large series of herbarium specimens of the *D. pallidum-D. currituckí* complex and concluded that the two species are inseparable. They found intergradation in every single character. The present chromosome observation, therefore, strengthens the evidence for combining *B. currituckí* and *D. pallidum*. (The latter name has priority.) It should be noted that *D. schimperi* (Lesq.) Par., a vicarious species closely resembling *D. pallidum* but confined to the west coast of the U. S., was reported by Steere, Anderson and Bryan (1954) to have the number, $n = 26$. This count, however, is also based on a single population from California. Counts from additional populations of *D. schimperi* would be very desirable in order to see if this closely related species also has both diploid and tetraploid populations. An Appalachian species, *D. henryi* Crum & Anders., has the number, $n = 13$ (Anderson & Bryan, 1958b), as determined from two populations, one from North Caro-

lina and one from South Carolina. Additional populations of this distinctive species should be investigated.

These observations on chromosome races in the highly variable *D. pallidum* serve to emphasize the need for caution in using chromosome data from single populations to interpret and evaluate specific concepts. Even where transplant experiments may indicate some degree of correlated genetic differences, as in *D. currituckí,* final disposition of the taxa should, if possible, await investigations of many widely distributed populations.

Pottiaceae

Weissia controversa Hedw.

$n = 13$; *fig.* 3-5

Two populations of this common weedy species were studied. In each, the number, $n = 13$, was found, which agrees with several previous counts (Steere, Anderson & Bryan, 1954; Bryan, 1956a; Sannomiya, 1955; Khanna, 1960a). Although Vaarama (1950b) reported a haploid number of 14 in a Finnish population, it seems likely that he failed to observe precocious disjunction of one of the smaller bivalents.

The complement of *W. controversa* consists of one large bivalent, twice or more the length of the other bivalents, 11 medium-sized, and one small bivalent (*fig.* 3). In figure 3, the large bivalent is in the top, left position of the figure and is shown with one median and two terminal chiasmata. It is usually the last bivalent to disjoin and may lag somewhat during anaphase I.

A remarkable size difference was observed in the sporocytes of the two populations investigated. Those of the Orange County population (*fig.* 4, 5) are twice the diameter of sporocytes from the Durham County population (*fig.* 3). Figure 4 is a polar view of metaphase I from the Orange County population, while figure 3 is a polar view of MI from the Durham County population. The two figures are drawn to the same scale. At first it was feared that material from one of the localities might have contained a mixture of species, but we checked carefully the identity of gametophytic plants from both localities and eliminated this possibility. The spore mother cell wall is shown in figure 5, which is a drawing from the Orange County population. This figure also shows a late anaphase of the first meiotic division in which the large chromosome can be identified in both anaphasic groups.

We are unable to explain size differences in the SMC of the two populations. Comparisons of morphological characters of plants from the two populations reveal no differences of any consequence. Both populations belong with *W. controversa* proper and not with

the var. *australis* (Aust.) Schornh. The latter differs in having somewhat taller setae which are reddish instead of yellowish, longer peristome teeth, and a longer urn, and the capsules mature earlier in the season. This variety has been studied cytologically by Anderson and Bryan (1958a), and the chromosomes do not differ in number or morphology from *W. controversa* itself.

Desmatodon plinthobius Sull. & Lesq.
$n = 39$; *fig.* 6-7

No previous chromosome counts have been recorded for this species. The chromosomes are somewhat sticky and difficult to spread apart, but we obtained preparations in which 39 bivalents were apparent. There is some variation in the size of meiotic chromosomes, and four of the smallest bivalents undergo disjunction in advance of the others (*fig.* 7). These precocious bivalents, however, are not small enough to qualify as m-chromosomes, although Steere, Anderson, and Bryan (1954) reported a single m-bivalent in a 13-chromosome species, *Desmatodon hendersoni* (Ren. & Card.) Grout.

This is the third species of *Desmatodon* in which chromosome counts have been reported. Anderson and Crum (1959) found 26 bivalents in *D. latifolius,* and in addition to the aforementioned *D. hendersoni,* $n = 13$, Steere (1954a) found the number, $n = 25$, in *D. cernuus* (Hüb.) BSG. Relationships among these species are at best obscure, and bryologists agree that the genus *Desmatodon* is largely artificial, comprising a group of dissimilar species. The haploid number, 13, or its multiple, is encountered throughout the Pottiaceae, and especially in *Tortula* and related genera. Evidence from chromosome numbers, therefore, is not likely to contribute substantially toward resolving the systematic position of the species now placed in *Desmatodon.*

FUNARIACEAE

Physcomitrium pyriforme (Hedw.) Brid.
$n = 27$: *fig.* 8-10

A single population of this moss was studied. Twenty-seven bivalents were observed, which confirms Bryan's (1957) observations on three other North American populations. Bryan has called attention to the strong tendency for the chromosomes of members of the Funariaceae to clump and adhere, and the chromosomes of *Physcomitrium pyriforme* are no exception. Preparations from which satisfactory counts can be made are exceedingly difficult to prepare. We found that chromosomes could be pressed apart more easily if heat was eliminated during the staining pro-

cedure with aceto-orcein. Intensification of the stain was achieved by adding additional dye under the cover glass after squashing and allowing the slide to stand for several hours. Excess dye was removed, and the cover glass was then sealed for study. Stubborn preparations were sometimes improved by storing at low temperatures (0° to 5° C.) from one to several days.

As reported by Bryan (*l.c.*), meiosis in *P. pyriforme* is regular, and no aberrant behavior was observed. A side view of MI is shown in figure 8. Precocious separation of bivalents is absent, and there is no tendency for bivalents to exhibit secondary pairing. At the spindle attachments, the chromosomes often become drawn out into long fiber-like processes (*fig.* 8 and 9), a fact that Bryan also observed, but, curiously enough this feature was not described by Wettstein (1930) or Schmidt (1931) in European material or by Pandé and Chopra (1957) in Indian populations. The significance of these fiber-like processes is not known. First anaphase figures indicated remarkable uniformity in disjunction, and lagging chromosomes were absent (*fig.* 10). Although only a relatively few populations have been studied, the races of *Physcomitrium pyriforme* in Europe, India, and North America possess distinctive chromosome numbers. According to Wettstein (1930) and Schmidt (1931) the original wild population of *P. pyriforme* from which the stocks for Wettstein's classical genetical experiments were derived possessed the number, $n = 36$, $2n = 72$. It is unfortunate that no additional chromosome counts have been made from other wild European populations of *P. pyriforme*. Pandé and Chopra (1957) described nine somatic chromosomes from antheridial squashes of *P. pyriforme* from "various" localities in the vicinity of Lucknow, India, and confirmed this count by observing nine bivalents at diakinesis in a number of sporocytes. As indicated above, the four populations studied from North America possess the number, $n = 27$.

The existence of interspecific chromosome races in this difficult species-complex is not unexpected. Wettstein (1930, 1932) was able to produce experimentally races of *P. pyriforme* with gametophytic numbers of 18 and 92 from plants that typically had the number 36. The presence of distinctive chromosome races, therefore, with the numbers, $n = 9$, 27, and 36, in India, North America, and Europe, respectively, arouses interest in the possible taxonomic significance of these races. The North American expression of *P. pyriforme*, called *P. turbinatum* Mx., was for many years considered by bryologists as a distinct species (see, *e.g.*, Britton, 1894; Grout, 1935). Britton ruled *P. pyriforme* out of the American flora because she found that it exhibited more uni-

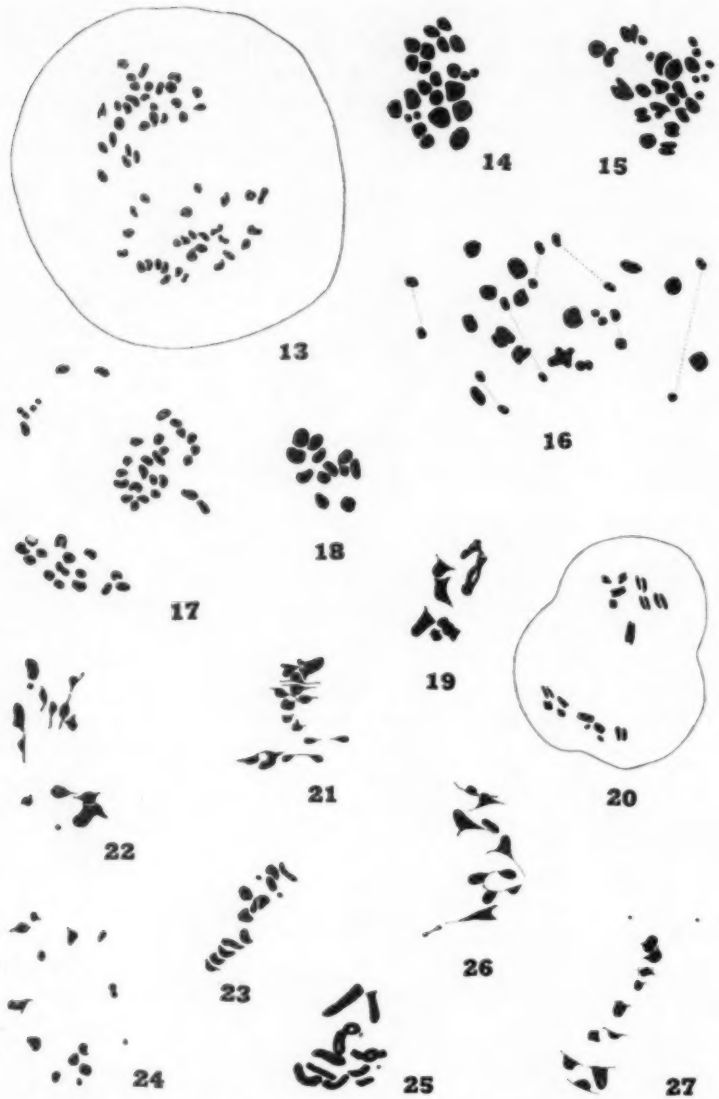

FIG. 13. *Funaria serrata* (continued), $n = 28$. Polar view of anaphase I showing 28 half-bivalents at each pole. FIG. 14-17. *Pohlia nutans* (Hedw.) Lindb., $n = 22$. 14. Polar view of MI showing 20 bivalents and four half-bivalents. Two bivalents have disjoined precociously. Note the tendency for bivalents to be arranged in groups of four. 15. Polar view of MI show-

form characters than *P. turbinatum*. After comparing a substantial series of specimens from Europe and North America, however, Crum and Anderson (1955) found the distinctions "at best vague and intangible," and concluded, in spite of chromosomal differences between the two species, that variation among American plants is so great that distinctions between *P. pyriforme* and *P. turbinatum* cannot be made on morphological grounds. The value of maintaining *P. turbinatum* purely on a geographic and chromosomal basis was deemed highly questionable by these authors, and they concluded that *P. turbinatum* could not be recognized.

Pandé and Chopra (1957) in their report of a 9-chromosome race of *P. pyriforme* in India, did not discuss taxonomic implications, but there is no reason to suspect that the Indian plants differ appreciably from the European *P. pyriforme*. Detailed morphological comparisons, however, are indicated. Additional cytological studies of many more populations of this wide-ranging species are needed before a sound taxonomic re-evaluation of this species-complex can be made.

Funaria serrata Brid.
$n = 28$; *fig.* 11-13

This is the first record of the chromosome number of this species. Restricted to the southern United States, it is a plant essentially of the Coastal Plain, where it is found usually on bare soil on roadbanks and the sides of ditches. The species has no

ing 18 bivalents and eight half-bivalents. 16. Side view of MI with chromosomes well spread apart from squashing, showing 14 bivalents and 16 half-bivalents; the respective homologs are connected by dotted lines. 17. Late anaphase I showing 44 half-bivalents. FIG. 18. *Aulacomnium heterostichum* (Hedw.) BSG, $n = 12$. Polar view of MI showing 12 bivalents. FIG. 19-20. *Bartramia pomiformis* Hedw., $n = 8$. 19. Early MI showing seven large bivalents and a small m-bivalent which has not yet disjoined. 20. Polar view of late anaphase I showing the half-bivalents near the poles; note in one of the anaphasic groups that the m-chromosome has already separated into its two sister chromatids in anticipation of second division. FIG. 21-22. *Ptychomitrium drummondii* Sull., $n = 13$. 21. Side view of MI showing disjunction of the small m-bivalent. 22. Polar view of MI showing m-bivalent already disjoined and in anaphase, while the remaining bivalents are still tightly synapsed. FIG. 23-24. *Ptychomitrium incurvum* (Schwaegr.) Sull., $n = 13$. 23. Side view of MI; note the precociously divided bivalent. 24. Polar view of MI showing 12 bivalents and two half-bivalents from an early disjunction of the m-bivalent; note that a second small chromosome is about to disjoin. FIG. 25-27. *Orthotrichum ohiocnse* Sull. & Lesq., $n = 11$. 25. Polar view of late diakinesis or early MI; note that the m-bivalent has already separated. 26. Polar view of MI showing disjunction of the m-bivalent. 27. Side view of MI showing the m-bivalent precociously disjoined and the half-bivalents almost at the poles.

close relatives in North America, but it resembles species found in South America and Australasia.

Meiotic figures revealed 28 bivalents, agreeing with counts reported for several other species of *Funaria*. The common and almost ubiquitous *F. hygrometrica* Hedw. consists of a number of chromosome races, $n = 14$ (Wettstein, 1930; Vaarama, 1953, 1955; Anderson & Crum, 1959), $n = 28$ (Vaarama, 1950a, 1956; Steere, Anderson & Bryan, 1954; Steere, 1954b; Bryan, 1957; Khanna, 1959, 1960b), and $n = 56$ (Bryan, 1957). The number, $n = 14$, has been reported for *F. calvescens* Schwaegr. (doubtfully distinct from *F. hygrometrica*) and *F. flavicans* Mx. by Pandé and Chopra (1958), while the number, $n = 28$, is known in *F. microstoma* BSG var. *obtusifolia* Grout (Steere, 1954a), *F. muehlenbergii* Turn. var. *patula* BSG (Steere, Anderson & Bryan, 1954; Steere, 1954b), and *F. wallichii* (Mitt.) Broth. (Khanna, 1960b). These data would suggest that the basic number for *Funaria* is probably seven, although the lowest number yet reported is 14.[4] This number contrasts with that of *Physcomitrium*, in which the basic number appears to be 9. Nevertheless, Wettstein (1928) hybridized *Physcomitrium pyriforme* and *Funaria hygrometrica*. Most of the spores from F_1 plants were sterile, but a few viable spores were produced.

There is a striking resemblance between the meiotic chromosomes of *Funaria* and *Physcomitrium*. Compare, *e.g.*, figure 8, which is a side view of MI of *P. pyriforme*, with figure 11, which is a comparable figure drawn from *F. serrata*. Note the presence in chromosomes of both species the previously described thread-like processes extending from the centromere. The chromosomes in both species are remarkably uniform in size, and notably absent are an especially large bivalent and a diminutive pair. In *Funaria serrata*, however, one of the smaller bivalents disjoins precociously (*fig.* 12) and reaches the poles during AI almost before the remaining bivalents start to disjoin. The precocious bivalent stains intensely. No meiotic irregularities were observed. Several AI figures were observed in which the chromosomes were well spread apart and clearly showed 28 half-bivalents in each anaphasic group (*fig.* 13). The uniform size relationship is also apparent in this figure.

[4] Beer (1903) reported the number, $n = 4$, for *Funaria hygrometrica*, and Beardsley (1931) estimated "ca. 10" chromosomes in gametophytic plants of *F. flavicans*, but since these counts were obtained, squash techniques for mosses have improved enormously. These two early counts are doubtless in error.

BRYACEAE

Pohlia nutans (Hedw.) Lindb.

$n = 22$; *fig.* 14-17

This exceedingly variable and widespread species has been repeatedly studied cytologically, and with the exception of an early estimate of "more than 14" by Heitz (1928) and the number, $n = 21$ (20 + 1), by Steere (1954a, b), all of the counts have indicated the number, $n = 22$ (20 + 2) (Yano, 1953a, 1956, 1957a; Vaarama, 1956). Our observations agree with the latter. We consistently observed 20 large bivalents and two smaller, precociously disjoining bivalents (*fig.* 14). The 20 larger bivalents can be grouped into five size classes of four bivalents each in a somewhat loose, but characteristic compound association (*fig.* 14-15). Bivalents show a strong tendency to adhere in groups of four, so that it seems highly unlikely that this appearance is coincidental. That these chromosomes are bivalents and not already disjoined half-bivalents was confirmed by observations of late anaphase I figures in which 44 half-bivalents could be identified with certainty (*fig.* 17).

Yano's (1957a) groupings of the somatic chromosomes of this species according to centromere position does not coincide with our meiotic observations. According to Yano, the karyotypic configurations are as follows: 2V(H) + 4J = 14 (4v + 10j) = 2m(h). He divides the complement into two size-groups, one comprising six larger chromosomes made up of two V- and four J-shaped ones and the other group consisting of 16 smaller chromosomes (4v, 10j, and 2m). Yano claims that the two largest V's and the two m's are the heterochromosomes (H and h, respectively). Yano interprets *Pohlia nutans* as a tetraploid species (sporophytically), pointing out that its karyotype is exactly the double of such diploid species as *P. acuminata* Hoppe & Hornsch., *P. revolvens* (Card.) Nog., *P. revoluta* (Card.) Ochi, *P. carnea* (Hedw.) Lindb., etc., which have the configuration, V(H) + 2J + 7 (2v + 5j) + m(h).

It is not possible, therefore, to relate the "tetrad"-like groupings of bivalents at metaphase I with the karyotypic configurations presented by Yano. At the same time it is possible to discern in Yano's (1957a) meiotic figure of *Pohlia nutans* (*fig.* 11-i, page 15) from Japan the same loose secondary association of bivalents that we have described above in the North Carolina population of this species. Yano does not direct attention to this feature.

Additionally, we have observed a consistent behavior pattern in the disjunction of bivalents in *P. nutans*. The two smallest bivalents disjoin first (*fig.* 14), while the remaining bivalents are

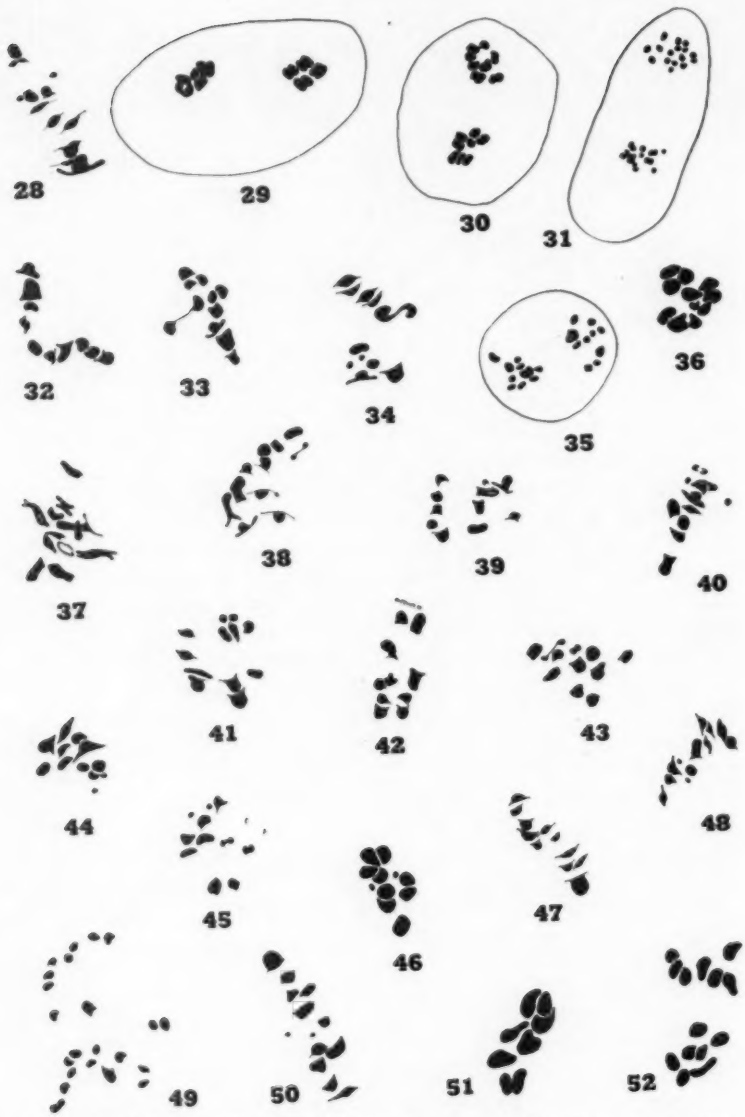

FIG. 28. *Hedwigia ciliata* (Hedw.) P.-Beauv., $n = 11$. Side view of MI showing 10 large bivalents plus two half-bivalents from a precociously disjoined m-bivalent. FIG. 29-31. *Ulota hutchinsiae* (Sm.) Hamm., $n = 16$. 29. Polar view showing secondary association of bivalents, comprising eight

still tightly synapsed. Two of the group of four smaller bivalents disjoin next, as evidenced by MI figures in which there are 18 bivalents and eight half-bivalents (*fig.* 15). The 12 large bivalents are the last to disjoin, frequently remaining in tight association until the previously disjoined half-bivalents have nearly reached the poles. Figure 16 shows an MI plate in which the chromosomes are well spread apart and in which the 12 large bivalents and two medium-sized bivalents have not disjoined. Fourteen half-bivalents are visible, and we have attempted to pair off the respective homologs with connecting dotted lines. An overwhelming majority of MI figures were observed to possess either 22 bivalents, 20 bivalents plus two half-bivalents, 18 bivalents plus eight half bivalents, or from 17 to 12 bivalents plus, respectively, 10 to 20 half-bivalents. This is interpreted to mean that after the smallest pair disjoins there is a time interval before the two bivalents disjoin.

tetrads each consisting of two bivalents. 30. Similar view but showing 16 bivalents. 31. Anaphase with 32 half-bivalents, 16 at each pole. FIG. 32-35. *Bryum argenteum* Hedw., $n = 10$. 32. Side view of MI showing 10 bivalents. 33. Side view of MI showing a large bivalent about to disjoin while the other bivalents are still tightly synapsed. 34. Polar view of MI; note the S-shape assumed by the large bivalent as it disjoins and a small chromosome which has already disjoined. 35. Polar view of anaphase I showing 10 half-bivalents near each pole; note that the half-bivalents from the large chromosome can be identified in each anaphasic group. FIG. 36. *Thelia asprella* Sull., $n = 11$. Polar view of MI showing 11 bivalents, one of which is small and not so dark. FIG. 37-40. *Leskea gracilescens* Hedw., $n = 11$. 37. Polar view of late diakinesis or early MI showing 10 bivalents and a lightly stained m-bivalent. 38. Side view of MI showing the m-bivalent about to disjoin. 39. Polar view of MI; the m-bivalent has disjoined. 40. Side view of MI showing the m-bivalent disjoined but with the two half-bivalents near each other. One regular bivalent has disjoined and is in early anaphase. FIG. 41. *Leskea obscura* Hedw., $n = 11$. Polar view of MI showing 10 bivalents and two half-bivalents of a precociously divided m-bivalent; the two half-bivalents stain weakly. FIG. 42-45. *Haplocladium microphyllum* (Hedw.) Broth., $n = 11$. 42. Polar view of MI showing 11 bivalents. The m-bivalent exhibits low stainability. 43. Polar view of MI showing 10 bivalents plus the m-bivalent in disjunction. 44. Polar view of MI showing 10 bivalents and two half-bivalents. 45. Polar view of MI showing nine bivalents and four half-bivalents. FIG. 46. *Rhynchostegium serrulatum* (Hedw.) Jaeg. & Sauerb., $n = 10$. Polar view of MI showing nine large, dark-staining bivalents plus two disjoined m-homologs. FIG. 47-49. *Hypnum lindbergii* Mitt., $n = 11$. 47. Side view of MI showing 11 bivalents one of which stains weakly. 48. Polar view of MI showing 10 bivalents and two weakly-stained half-bivalents. 49. Polar view of anaphase I showing 11 evenly stained half-bivalents near each pole. FIG. 50. *Isopterygium micans* (Sw.) Broth., $n = 12$. Side view of MI showing 11 bivalents and a small m-bivalent precociously divided into two half-bivalents. FIG. 51-52. *Atrichum angustatum* (Brid.) BSG, $n = 7$. 51. Polar view of MI showing seven bivalents. 52. Polar view of anaphase I.

A group of six medium-sized bivalents then disjoin singly over a period of time, after which, finally, the 12 large bivalents disjoin simultaneously or nearly so.

Anaphase figures reveal 44 half-bivalents (*fig.* 17), and there is no indication of abnormal behavior, other than the pole-ward movement of half-bivalents successively by groups as described above. No chromatin bridges were seen, and we observed no sporocytes in which chromosomes were excluded from daughter nuclei. Fertility of spores, judging from appearance only, would appear to be high.

Bryum argenteum Hedw.
$n = 10$; *fig.* 32-35

In spite of the large number of investigations of this widespread and usually weedy species, there is still some question concerning the correct chromosome number for North American populations. Investigations of European (Jachimsky, 1935), Japanese (Yano, 1956, 1957a), and Indian (Chopra, 1957) populations uniformly have indicated that the haploid number is 10. Steere, Anderson and Bryan (1954), however, reported the number, $n = 12$, for a Californian population identified as var. *lanatum* BSG, but Anderson and Bryan (1958a) reported the number, $n = 10$, for a population of *B. argenteum* from the Piedmont of North Carolina. The morphological characters upon which var. *lanatum* are based are very weak, and it is not a strong taxonomic entity. Considering the enormous variability of the species proper, which is found in nearly all parts of the globe, it is surprising indeed that var. *lanatum* should possess a different chromosome number.

The population examined here afforded favorable material for meiotic studies. We examined numerous capsules, and excellent preparations of meiotic metaphases were obtained with remarkable ease. The chromosomes stained intensely with aceto-orcein, and they were easily spread apart by the squash method. Ten bivalents were consistently observed (*fig.* 32) at MI. An identifiable large bivalent is nearly always the first bivalent to disjoin (*fig.* 33), and the resulting two half-bivalents are large enough to be mistaken for half-bivalents. In figure 33, the large bivalent has nearly completed disjunction. In some sporocytes the smallest bivalent was observed to undergo disjunction simultaneously with the large bivalent (*fig.* 34), but otherwise meiosis is regular. Anaphase figures clearly reveal 10 half-bivalents in each group (*fig.* 35), and it is possible, as shown in figure 35, to identify the large chromosome in nearly all anaphase figures.

AULACOMNIACEAE

Aulacomnium heterostichum (Hedw.) BSG

$n = 12$; *fig.* 18

Anderson and Bryan (1958a) studied a single population of this distinctive moss and similarly found the number, $n = 12$. The dioicous species of this genus that have been studied likewise have a haploid number of 12, including *A. palustre* (Hedw.) Schwaegr. (Steere, Anderson, & Bryan, 1954), *A. turgidum* (Wahl.) Schwaegr., and probably *A. androgynum* (Hedw.) Schwaegr. (reported by Heitz, 1945, to have the number, $n = 10$-11, but probably erroneously, judging from other counts made subsequent to modern improvements in squash techniques for mosses). As *A. heterostichum* is autoicous, the species might have been expected to have a polyploid number. Furthermore, LaRue (1929) found that *A. heterostichum* could be regenerated by the aposporous production of leafy gametophytes from sporophytes, and so an easy mechanism for polyploidy is known to exist.

BARTRAMIACEAE

Bartramia pomiformis Hedw.

$n = 8$; *fig.* 19-20

Numerous chromosome counts have been made of this moss, including populations from North America, Japan, and Europe (see Anderson & Bryan, 1958a), and the number, $n = 8$, uniformly has been reported. There are seven large bivalents and a small precociously disjoining m-bivalent (*fig.* 19). One conspicuously longer and larger bivalent is evident, and the other bivalents show marked size differences, borne out in Lowry's (1954) and Yano's (1955, 1957a) karyotypic configurations. It is apparent from observations of a number of sporocytes that the m-chromosome separates into its respective sister chromatids precociously while moving toward the anaphase I pole. This is shown in figure 20, where one of the half-bivalents of the m-chromosome has already separated, so that one of the polar groups contains seven half-bivalents and two sister chromatids.

Cytotaxonomic aspects of *Bartramia* have been discussed by Holmen (1958) and Anderson and Bryan (1958a).

PTYCHOMITRIACEAE

Ptychomitrium drummondii Sull.

$n = 13$; *fig.* 21-22

This is the third population of this species that has been studied cytologically, and the number, $n = 13$, agrees with that previously

published by Anderson and Bryan (1958a) for two Piedmont populations. Eleven normally-disjoining bivalents (*fig.* 21) and two smaller bivalents that disjoin precociously were observed in the present material. One of the two smaller bivalents is obviously an m-bivalent, for it regularly disjoins early, is lighter-staining, and apparently lacks chiasmata. The second small bivalent, also observed by Anderson and Bryan, is likewise visible in figure 21, in the lower part of the figure, and is about to separate. Unlike the m-bivalent, however, it does not always disjoin early. In figure 22, for instance, the half-bivalents from the m-chromosome are already in late anaphase, but the remaining bivalents, including the aforementioned small bivalent, are still in metaphase condition. Apparently, therefore, there is only a single m-chromosome in *P. drummondii.*

Ptychomitrium incurvum (Schwaegr.) Sull.
$n = 13$; *fig.* 23-24

This is the first report of the chromosome number of this common rupestral species of eastern North America. The chromosomes are remarkably similar to those of *P. drummondii,* including the presence of a small precociously disjoining m-chromosome (*fig.* 23) and a second small chromosome that occasionally, although by no means always disjoins early. In figure 24, the half-bivalents from the small m-bivalent are shown on the right of the figure, which is a polar view of MI, while the other small bivalent is shown at about 3 o'clock in the figure and is about to disjoin.

The two species of *Ptychomitrium* reported on here are closely related. They are both included in sect. NOTARISIA (Hampe) Broth. by Brotherus (1925); this is a small group of less than five species, one from southern Europe and the others from North America. Similarities of morphology and behavior of meiotic chromosomes between the Ptychomitriaceae and Orthotrichaceae noted by Anderson and Bryan (1958a) support the close positions accorded them by most bryologists.

ORTHOTRICHACEAE

Ulota hutchinsiae (Sm.) Hamm.
$n = 16$; *fig.* 29-31

This is the first report of the chromosome number of this species from North American material. Ho (1956) reported the number, $n = 10$, for a European population. In the single population we studied we are fairly certain that the haploid number is 16, but propose this number with some hesitance. We found the number difficult to resolve because of the strong tendency of the

bivalents to clump into two groups of apparently eight bivalents each (*fig.* 29, 30). Furthermore, we observed very strong secondary pairing of bivalents. This so-called secondary association is especially apparent in early MI and is shown in figure 29. Because of the secondary pairing it was first thought that the *n*-number might be eight. First division anaphase figures, however, revealed fairly clearly 16 half-bivalents in each anaphasic group. But owing to the difficulty of interpretation and the scarcity of material, we are reporting the number, $n = 16$, with reservations. This species should provide rewarding material for a detailed study of meiosis.

Orthotrichum ohioense Sull. & Lesq.
$n = 11$; *fig.* 25-27

Anderson and Bryan (1958a) studied a single population of this small epiphyte on trunks of hardwood trees and reported 10 large bivalents and one small lightly-stained m-chromosome at MI. We have studied two additional populations with the same number. A single capsule was found in which some of the sporocytes were in diakinesis (*fig.* 25), a stage not frequently observed in mosses. It should be noted in this figure that the small m-chromosome has already divided, and two of the larger chromosomes show chiasmata, at least three in one of the chromosomes and at least two in another. Such configurations have not previously been figured for *Orthotrichum.*

The half-bivalents of the m-chromosome often remain attached by thin threads following disjunctions, as shown in figure 26. The time of disjunction of the m-bivalent apparently is variable. In some sporocytes, as shown in figure 25, *e.g.,* the m-chromosome divides quite early, during late diakinesis or early MI, while in other sporocytes the m's remain at least distantly attached until the larger bivalents begin to disjoin (*fig.* 26). Heitz (1928a), among others, has demonstrated the lack of chiasmata in the m-chromosome and has pointed out that conjugation of the m-pair is by matrix only, which is only a step beyond distance conjugation. Lack of chiasmata is probably the reason why disjunction of m-bivalents occurs precociously.

HEDWIGIACEAE

Hedwigia ciliata (Hedw.) P.-Beauv.
$n = 11$; *fig.* 28

Vaarama (1950a, 1954) reported the number, $n = 22$, from Finnish material of *H. ciliata,* while Steere, Anderson, and Bryan (1954) found the number, $n = 11$, in a Californian population.

It was with more than casual interest, therefore, that we examined a population from eastern U. S. We observed 11 bivalents, thus establishing similar numbers in eastern and western populations. This species has an exceedingly wide geographic distribution, occurring in practically every continent, and it is exceedingly variable in morphology. It is not surprising, therefore, to find chromosome races, and the desirability of additional studies, especially on other continents, of this moss are indicated.

As described by Steere, Anderson, and Bryan, there are 10 large bivalents plus one small precociously disjoining m-chromosome (*fig.* 28). Vaarama (1954) studied meiosis in Finnish populations of *H. ciliata* in great detail but reported only a single m-bivalent, which he termed a "special bivalent." He found that homologs of the "special bivalent" or m-chromosome pair off only at a distance and separate during late diakinesis or early MI. We were able to study meiosis in the 11-chromosome race of *H. ciliata* and will report results of this study in a separate publication.

THELIACEAE

Thelia asprella Sull.

$n = 11$; *fig.* 36

No previous report is known of the chromosome number of this small family of three genera and less than a dozen species. Satisfactory preparations of the chromosomes of *Thelia asprella* were exceedingly difficult to obtain. The bivalents at MI tend to clump into a tight aggregation that almost defies attempts to press them apart, and the chromosomes are sticky and aggregate in groups of varying numbers. Only a very few sporocytes were observed in which the chromosomes could be counted with reasonable confidence. There seems to be little doubt, however, that the haploid number is 11, comprising 10 large, dark-staining bivalents and a small, light-staining chromosome (*fig.* 36) that is probably an m-bivalent. The number, $n = 11$, is in line with numbers reported for allied families, notably the Leskeaceae, in which *Thelia* has been placed by some (*e.g.,* Grout, 1934).

LESKEACEAE

Leskea gracilescens Hedw.

$n = 11$; *fig.* 37-40

The chromosomes of only a single species belonging to this large family have been investigated previously. Vaarama (1956) reported the number, $n = 13(11 + 2)$, for *Leskea polycarpa* Hedw. from Northern Ireland. He observed 11 large, normally-

separating bivalents plus two bivalents of "m-chromosome type."

We studied a single population of *L. gracilescens,* from Wake County, North Carolina, kindly provided by Dr. Richard Forman. The material bore a large quantity of capsules in various stages of maturity, and we were able to secure abundant stages of meiosis. Early prophases were studied in some detail.

The haploid number is unmistakably 11, consisting of nine relatively large bivalents and two smaller bivalents. The smallest bivalent is the m-chromosome, which is heteropycnotic and visible in a condensed state in interkinetic nuclei of both gametophytic and sporophytic tissue. In gametophytic tissue the m-chromosome at interkinesis appears as a single, darkly stained body, often located near the nucleolus, but it does not appear to be a nucleolar organizer. In sporophytic tissue, as would be expected, there are two heteropycnotic m-bodies. During early prophase of meiosis the two heteropycnotic m-homologs pair at a distance and remain "distantly conjugated" until about diplotene or early diakinesis. Typically, during the period of distance conjugation the m-chromosomes are C-shaped or in the shape of a quarter-moon, and often were observed back-to-back from three to six microns apart to almost touching. At diakinesis, the m's finally "synapse" (*fig.* 34). When pairing is completed, the m-bivalent loses much of its affinity for orcein and stains only faintly during diakinesis and MI.

The m-homologs remain in close contact throughout diakinesis, but obviously without chiasmata. Because it stains so faintly, the m-bivalent could easily be overlooked. The remaining 10 bivalents pair normally during meiotic prophases, show evidence of chiasmata (*fig.* 37), and stain darkly at metaphase I (*fig.* 38-40). During late diakinesis or prometaphase the m-bivalent disjoins precociously (*fig.* 38-39) but does not begin anaphasic movement until the larger bivalents initiate disjunction. The m half-bivalents thus do not reach the poles in advance of the regular half-bivalents. In figure 39, which shows the chromosomes in early MI, the m-bivalent has disjoined. A later figure (*fig.* 40), however, in which one of the regular bivalents has already disjoined and begun anaphasic movement, shows the half-bivalents of the m still only slightly separated. Anaphasic movement of the m-chromosomes occurs concurrently with the regular chromosomes.

Leskea obscura Hedw.
$n = 11$; *fig.* 41

This is the first report of the chromosome number of this poorly understood species. Although we were unable to observe

meiotic prophases, at MI we clearly observed 10 large bivalents plus an m-bivalent which dissociates precociously (*fig.* 41). It seems probable that the same behavior occurs in *L. obscura* as was described for *L. gracilescens*.

Vaarama (1956), as pointed out above, described two m-bivalents in *L. polycarpa*, plus 11 regular bivalents of larger size and darker staining characteristics. It is significant to find aneuploid differences among species of *Leskea* and to find that the differences involve both regular and m-chromosomes. The presence of similar complements in *L. gracilescens* and *L. obscura* is borne out by close taxonomic resemblances between the two species, and the aneuploid differences between these latter species and *L. polycarpa* are in line with the fact that *L. polycarpa* exhibits fewer similarities to *L. gracilescens* and *L. obscura*.

The genus *Leskea*, although containing fewer than 15 species, is notoriously difficult taxonomically. The discovery of clear-cut chromosome differences among species is, therefore, significant. Chromosome studies of additional species may aid in the elucidation of species.

Thuidiaceae

Haplocladium microphyllum (Hedw.) Broth.
$n = 11$; *fig.* 42-45

Two populations of this moss were studied, and in both the number, $n = 11$, was determined. There are 10 larger, dark-staining bivalents plus a small m-bivalent. This number agrees with previous counts of this species from populations from Arizona and Florida (Al-Aish & Anderson, 1960a, d) but does not agree with Sannomiya's report, $n = 10$, from Japanese populations. Apparently, the small m-bivalent is absent in the Japanese plants. Two other Japanese species, *Haplocladium capillatum* (Mitt.) Broth. and *Haplocladium subulaceum* (Mitt.) Broth. [including the var. *subulatum* (Card.) Thér.] are reported to have the number, $n = 10$, and also apparently lack the m-bivalent (Kurita, 1950; Sannomiya, 1958; Yano, 1950, 1957b, 1957d).

In the North Carolina populations of *H. microphyllum*, there are two precociously dividing bivalents (*fig.* 43). One of these is the m-bivalent, which is tiny, stains lightly (*fig.* 42), and is the first to undergo disjunction (*fig.* 43). After separating, the m-homologs move a short distance apart, where they remain until the larger bivalents begin to divide (*fig.* 44). In the meantime, the smallest of the dark-staining bivalents undergoes disjunction, resulting in figures of nine bivalents and two pairs of half-bivalents (*fig.* 45). The second of the precociously dividing bivalents ap-

parently is not a m-chromosome. It stains darkly throughout both divisions and probably is not heteropycnotic, although we were not able to determine this with certainty.

Brachytheciaceae

Rhynchostegium serrulatum (Hedw.) Jaeg. & Sauerb.
$n = 10$; *fig.* 46

Anderson and Bryan (1958a) reported the number, $n = 9$, for this species, but we are inclined to interpret the number, $n = 10$, for a population collected in the same general area. The number is probably the same in the two populations, but the chromosome configurations are exceedingly difficult to interpret. There is a clearly recognizable m-bivalent, which divides precociously (*fig.* 46), also described by Anderson and Bryan. The regular bivalents are difficult to spread apart, and it is difficult to determine whether two of the larger chromosomes are individual bivalents or whether they are precociously separated half-bivalents. Anderson and Bryan regarded them as half-bivalents, observing in many sporocytes a single large chromosome and seven other dark-staining chromosomes plus the m-bivalent. The present study leads us to interpret this large chromosome as a compound bivalent in which two bivalents adhere through stickiness. Good anaphase figures are needed to resolve the question, but stickiness of chromosomes seems to increase during anaphase and our preparations of these stages were unsatisfactory.

Hypnaceae

Hypnum lindbergii Mitt.
$n = 11$; *fig.* 47-49

This is the first report of the chromosome number from a North American population of this species. We observed 11 bivalents, 10 that stain intensely and a small light-staining m-bivalent (*fig.* 47). The m-bivalent divides early (*fig.* 48), but the resulting homologs move apart only a short distance and remain there until disjunction is completed.

Of the dark-staining bivalents, one is conspicuously larger (*fig.* 47). The homologous chromosomes from this large bivalent are especially noticeable in anaphase I (*fig.* 49), which clearly shows 11 half-bivalents in each anaphasic group.

Yano (1953a, 1957b) reported only 10 bivalents in Japanese populations of *H. lindbergii* [as *Breidleria arcuata* (Lindb.) Loeske], and the same number was found in the closely related species, *H. pratense* Koch (also as *Breidleria*), and *H. homaliaceum* (Besch.) Doign. Yano's counts were made from gameto-

phytic material, and may not have included an m-chromosome, although Yano offered the karyotype, $K(n) = 10 = V(H) + 2V + 6(2v + 4j) + m(h)$, for all three species in the *Breidleria* relationship. Yano automatically assumes that the largest and smallest chromosome of any complement in mosses are heterochromosomes, macro- and micro-[designated by the letters M for the large heterochromosome and h for the small heterochromosome, nearly always assumed to be an m-chromosome (see Yano, 1957a)]. If the species involved, furthermore, is dioicous, Yano assumes that the large H heterochromosome is a sex chromosome and boldly designates them as X and Y chromosomes. Thus, Yano designates *H. lindbergii*, which is dioicous, as follows: ♀ X + 9, ♂ Y + 9. Although these assumptions may in time prove to be correct, at present there is little or no evidence to support them. His drawings of so-called X and Y chromosomes from archegonial and antheridial plants, respectively, purporting to show size differences, are not convincing. Although heteropycnosis has been shown in a few plants and animals to be associated with sex chromosomes, it is not by any means established that heteropycnotic chromosomes are always sex chromosomes. There is abundant evidence in hepatics for a structural chromosomal sex determining mechanism, but no one has yet demonstrated the presence of a sex chromosome mechanism in mosses, in spite of countless reports of X and Y chromosomes in these plants by Yano (summarized, 1957a, 1957b, 1957c) and others.

Isopterygium micans (Sw.) Broth.
$n = 12$; *fig.* 50

Three populations of this common and exceedingly variable moss were studied. The number, $n = 12$, was observed in all of them, which is in agreement with a previous report of a population from Florida by Al-Aish and Anderson (1960d). There are 11 regular bivalents plus a small m-bivalent which divides precociously (*fig.* 50). Thus a haploid number of 12 seems to be established for this species, which does not agree with previous counts for other species of *Isopterygium*. Vaarama (1950a) found the number, $n = 11$, in *I. turfaceum* (Lindb.) Lindb., while Anderson and Crum (1959) reported the numbers, $n = 11$, and $n = 22$, respectively, for two populations of *I. pulchellum* (Hedw.) Jaeg. & Sauerb. from the Canadian Rocky Mountains. The small m-bivalent was not observed in either of the latter species, however, which doubtless accounts for the differences in chromosome number between these two species and *I. micans*.

POLYTRICHACEAE

Atrichum angustatum (Brid.) BSG
$n = 7$; *fig.* 51-52

This species has been repeatedly investigated, cytologically, and all the populations studied have the number, $n = 7$ (*fig.* 51). An early report of the number, $n = 8$, by Ikeno (1904) is unquestionably erroneous. In the present population which was clearly dioicous (δ plants seen), we observed seven bivalents and have drawn an anaphase I figure in which there are seven half-bivalents in each of the anaphasic groups (*fig.* 52). North American species of *Atrichum* are in much need of taxonomic revision. The distinctions between *A. angustatum* and *A. undulatum* are not clear, and there are indications that chromosome studies may help elucidate the problem. Noguchi and Osada (1960), for example, have utilized Tatuno's (1960) chromosome data (counts on more than 100 populations of the three common Japanese species) in clarifying the *A. undulatum* complex in Japan. Three chromosome numbers, $n = 7$, $n = 14$, and $n = 21$, formed the principal character around which three respective varieties, namely, var. *minus*, var. *undulatum*, and var. *haussknechtii*, could be re-defined and re-described. A sound cytotaxonomic study of the genus in North America is indicated.

TABLE I. Summary of Chromosome numbers.

Species and source	Specimen Number	Chromosome Number	Figure
DITRICHACEAE			
Ditrichum pallidum (Hedw.) Hampe			
Durham Co., N. C.	14025	$n=13$	1 - 2
POTTIACEAE			
Weissia controversa Hedw.			
Durham Co., N. C.	14026	$n=13$	3
Orange Co., N. C.	14027	$n=13$	4 - 5
Desmatodon plinthobius Sull. & Lesq.			
Orange Co., N. C.	14028	$n=39$	6 - 7
FUNARIACEAE			
Physcomitrium pyriforme (Hedw.) Brid.			
Durham Co., N. C.	14029	$n=27$	8 - 10
Funaria serrata Brid.			
Durham Co., N. C.	14030	$n=28$	11 - 13
BRYACEAE			
Pohlia nutans (Hedw.) Lindb.			
Bladen Co., N. C.	14031	$n=22$	14 - 17
Bryum argenteum Hedw.			
Durham Co., N. C.	14032	$n=10$	32 - 35
AULACOMNIACEAE			
Aulacomnium heterostichum (Hedw.) BSG			
Orange Co., N. C.	14033	$n=12$	18

TABLE I. Continued.

Species and source	Specimen Number	Chromosome Number	Figure
BARTRAMIACEAE			
Bartramia pomiformis Hedw.			
Durham Co., N. C.	14034	$n = 8$	19 - 20
PTYCHOMITRIACEAE			
Ptycomitrium drummondii Sull.			
Orange Co., N. C.	14035	$n = 13$	21 - 22
P. incurvum (Schwaegr.) Sull.			
Orange Co., N. C.	14036	$n = 13$	23 - 24
ORTHOTRICHACEAE			
Ulota hutchinsiae (Sm.) Hamm.			
Stokes Co., N. C.	14037	$n = 16$	29 - 31
Orthotrichum ohioense Sull. & Lesq.			
Durham Co., N. C.	14038	$n = 10+1$	25
Orange Co., N. C.	14039	$n = 10+1$	26 - 27
HEDWIGIACEAE			
Hedwigia ciliata (Hedw.) P.-Beauv.			
Durham Co., N. C.	14040	$n = 10+1$	28
THELIACEAE			
Thelia asprella Sull.			
Durham Co., N. C.	14041	$n = 11$	36
LESKEACEAE			
Leskea gracilescens Hedw.			
Wake Co., N. C.	14042	$n = 10+1$	37 - 40
L. obscura Hedw.			
Durham Co., N. C.	14043	$n = 10+1$	41
THUIDIACEAE			
Haplocladium microphyllum (Hedw.) Broth.			
Durham Co., N. C.	14044	$n = 10+1$	42 - 43
Durham Co., N. C.	14045	$n = 10+1$	44 - 45
BRACHYTHECIACEAE			
Rhynchostegium serrulatum (Hedw.) Jaeg. & Sauerb.			
Orange Co., N. C.	14046	$n = 10$	46
HYPNACEAE			
Hypnum lindbergii Mitt.			
Durham Co., N. C.	14047	$n = 11$	47 - 49
Isopterygium micans (Sw.) Broth.			
Durham Co., N. C.	14048	$n = 12$	50
POLYTRICHACEAE			
Atrichum angustatum (Brid.) BSG			
Durham Co., N. C.	14049	$n = 7$	51 - 52

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LUISIERELLA BARBULA IN GEORGIA

HOWARD CRUM AND LEWIS E. ANDERSON[1]

Luisierella barbula (Schwaegr.) Steere, like so many of the Pottiaceae, is an obligate calciphile, widespread in the lowlands of tropical America where limestone rocks abound, but easily overlooked because of its very small size, modest appearance, and generally scattered habit of growth. Microscopically it is very distinct and very easily recognized. Its leaves, lingulate and rounded at the tip, have hyaline, abruptly inflated basal cells which extend upward a short distance along the margins, suggesting the bordered leaf shoulders of *Tortella* or *Barnesia*. The basal cells provide a striking contrast with the small, green and bulging or mammillose upper cells. The densely papillose peristome teeth are erect, very short and irregular (entire, unequally cleft, or perforate, sometimes rudimentary or apparently lacking). The annulus is well developed and persistent.

In Grout's *Moss Flora* the species is slipped into the appendix to volume 2 (under "Additions and Corrections to Volume I") as *Desmatodon barbula* (Schwaegr.) Grout. Before that, it had had a checkered taxonomic history, with synonyms under *Gymnostomum, Hyophila, Pottia, Weissia, Tortula,* and *Gyroweisia*. It appears as *Gyroweisia barbula* (Schwaegr.) Par. in the second edition of Paris' *Index Bryologicus* (p. 22) and as a synonym of *G. cubensis* Broth. in Engler and Prantl's *Die natürlichen Pflanzenfamilien* (ed. 1, vol. 1(3), p. 389, and ed. 2, vol. 10, p. 256). Grout said, "There seems to be absolutely no characters to separate this from *Desmatodon*. *Gyroweisia* as generally treated seems to be a highly synthetic genus." *Gyroweisia* is indeed an artificial genus, as treated in Engler and Prantl, but in a purified sense, including at least our North American species, *G. reflexa* (Brid.) Schimp. and *G. tenuis* (Hedw.) Schimp., it is quite a respectable genus, similar to *Luisierella* in leaf shape, well differentiated annulus, and poor development of peristome. It is even more obvious that *Desmatodon*, especially as treated by Grout, is a dumping ground, rather than a genus. *Luisierella* is only distantly related to any other species which Grout, and earlier Williams, threw into it.

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Luisierella is, in fact, a very good and very distinctive genus, as Steere (1945) has clearly demonstrated.

The distribution of the species was summarized by Steere (1945) as Florida, Bermuda, the Bahamas [New Providence and Abaca], Cuba, Haiti, Puerto Rico, Jamaica, British Honduras, and Brazil. A number of subsequent reports add confirmation to that statement: British Honduras (Steere, 1946), Cuba (Welch, 1950), Haiti (Crum & Steere, 1958), Jamaica (Welch & Crum, 1960), Puerto Rico (Crum & Steere, 1957), and Florida (Crum & Anderson, 1960). Whitehouse and McAllister (1954) added central Texas to the range; the species had been collected there by Frederick McAllister on wet limestone at Hamilton Pool west of Austin, Travis County, January 15, 1933. (We have verified the determination.)

Ruth Schornherst (1940) was the first to find the species in North America. She collected it, presumably in 1939, on limestone at Wakulla Springs, Wakulla County, northern Florida. (Material collected there on November 19, 1939 by Ruth Schornherst and A. J. Grout was distributed as no. 388 of Grout's *North American Musci Perfecti*). Schornherst later (1943) reported collections from limestone at the Devil's Millhopper (Alachua Co.), Withlacoochie River (Madison Co.), and Aspalaga (Gadsden Co.). In 1943 she added Jackson County, without further data. To these county records, all from northern Florida, can be added an unpublished record from Leon County, also in the northern part of the state: On calcareous rocks, sink holes, Appalachicola National Forest, about 10 miles south of Tallahassee, *Paul L. Redfearn, Jr.*, 1179, December 31, 1955; a specimen at Southern Methodist University was made available through the kindness of Dr. Eula Whitehouse.

Records from southern Florida were contributed by Crum and Anderson (1960), who made collections on limestone near Miami and Homestead and also at Royal Palm Hammock, all in Dade County.

On March 31, 1960, we paid a hurried visit to a small limestone cave in southwest-central Georgia ("Rock House Cave," about five miles southeast of Cordele, Crisp Co.). We had spent hours trying to find the place, which turned out to be in a horse pasture, badly disturbed by men and livestock, and it was almost dusk when we arrived, so that we could only make a few grabs at what appeared to be a dull and weedy flora. For the record, we collected *Fissidens bushii* Card. & Thér.) Card. & Thér., *F. cristatus* Wils. *ex* Mitt. & Wils., *F. taxifolius* Hedw., and *Campylium chrysophyllum* (Brid.) J. Lange, all common in the South and often as-

sociated with a limey substrate. *Barbula cruegeri* Sond. *ex* C.M. and *Weissia jamaicensis* (Mitt.) Grout were also found; both are obligate calciphiles particularly common in the American tropics. The only species of real interest, a first record for the state, was *Luisierella barbula,* which grew in some abundance some 40 or 50 feet from the cave on dry limestone walls of the brook issuing from the cave as a small waterfall. The specimen (*Anderson* & *Crum* 13772) is represented in duplicate at Duke University and the National Museum of Canada.

LUISIERELLA BARBULA (Schwaegr.) Steere, Bryol. 48: 84. 1945.

Gymnostomum barbula Schwaegr., Suppl. Sp. Musc. II. 2(1): 77. 1826.
Hyophila barbula (Schwaegr.) Hampe, Bot. Zeit. 4: 267. 1846.
Pottia barbula (Schwaegr.) C. M., Syn. Musc. Frond. 1: 558. 1849.
Weisia barbula (Schwaegr.) Mitt., Jour. Linn. Soc. London, Bot. 12: 136. 1869.
Tortula melanocarpa Mitt., *Ibid.* 15: 60. 1876.
T. barbula (Schwaegr.) Mitt., Rept. Voy. Challenger, Bot. 1(1): 91. 1885, hyponym.
Hymenostylium barbula (Schwaegr.) Mitt., *Ibid.* 1(1): 91. 1885, hyponym.
Gyroweisia cubensis Broth. *in* E. & P., Nat. Pfl. 1(3): 389. 1902, *nom. mut.* for *Weisia barbula* (Schwaegr.) Mitt.
G. barbula (Schwaegr.) Par., Index Bryol. (ed. 2.) 2: 299. 1904.
Tuerckheimia barbula (Schwaegr.) Hilp., Beih. Bot. Centralbl. 50(2, 3): 656. 1933.
Luisierella pusilla Thér. & P.-V. *in* P.-V., Bull. Soc. Bot. France 83: 74. 1936.
L. stenocarpa Biz. & Thér. *in* Thér., Mem. Soc. Cubana Hist. Nat. 13: 273. 1939.
Desmatodon barbula (Schwaegr.) Grout, Moss Fl. No. Amer. 2(5): 271. 1940.

Plants very small, up to 1.5 or 2 mm. high, dull, dark green or blackish when dry. Stems erect, simple. Leaves crowded in a rosulate tuft, rolled lengthwise and contorted when dry, spreading when moist, about 1-1.5(2) mm. long, lingulate or oblong, rounded or rounded-obtuse at apex, concave; margins erect, crenulate above, entire at base; costa single, ending 4-5 cells below the leaf tip, covered with green, bulging cells similar to those of the lamina above, with about 2 median guide cells and a small group of dorsal stereids; upper cells 8-12 μ, with firm or incrassate walls, irregularly rounded-hexagonal and often slightly wider than long, bulging or mammillose on the upper surface, plane or nearly so on the lower, green, basal cells abruptly enlarged and inflated, hyaline, oblong, lax, and thin-walled, extending farther up the margins than at the costa to form a V-shaped border ending slightly above the shoulders. Dioicous. Seta 4-5(9) mm. long, erect, red; urn

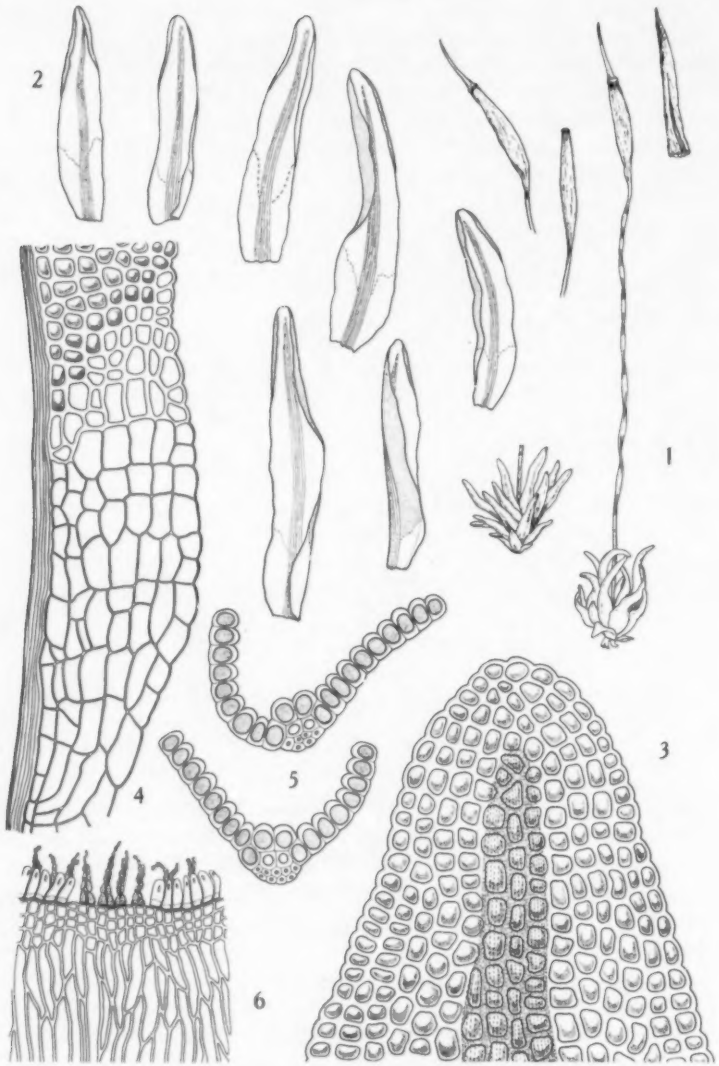

FIG. 1-6. *Luisierella barbula*. 1. Habit of fruiting plant, dry and moist, with extra capsules showing tendency to slight curvature and a calyptra, × 12.5. 2. Leaves, × 31.5. 3. Cells at apex of leaf, × 325. 4. Cells at basal margin of leaf, × 239. 5. Cross-sections of upper portion of leaf, × 239. 6. Portion of peristome and persistent annulus, × 134. (*All drawings were prepared by Lynn Bartosch.*)

of capsule 1.25-2 mm. long, erect and symmetric or slightly curved and suberect, narrowly cylindric, smooth; annulus compound, narrow but well developed, persistent; operculum narrowly high-conic, about ½ as long as the urn, about 0.7-1 mm. long; peristome teeth 16, erect, linear or narrowly lanceolate, very short (sometimes only slightly exceeding the annulus), irregular, densely papillose. Spores 8-9 μ, spherical, smooth or nearly so. Calyptra cucullate, smooth. (*Fig.* 1-6.)

The attractive watercolors accompanying Schwaegrichen's original description are commendable representations of the species (Schwaegrichen, 1826, pl. 175); the acute leaf tips are inaccurate, however. Adequate illustrations are provided in Grout's *Moss Flora* (vol. 2, fig. 12-19 by R. S. Williams, fig. 20 by Seville Flowers; the latter is a very good picture of the peristome). Potier de la Varde's graceful sketches of *Luisierella pusilla* Thér. & P.-V., a Brazilian synonym of *L. barbula,* are very good, except that the bulging upper leaf cells are not well shown (Potier de la Varde, 1936). Portions of Potier de la Varde's plate are reproduced by Crum and Steere (1957). Thériot's figures of *L. stenocarpa* Biz. & Thér. (Thériot, 1939) are acceptable but too cramped in style to be very serviceable. The illustrations accompanying this paper were drawn by LYNN BARTOSCH of the National Museum of Canada.

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THE TAXONOMIC STATUS OF GRIMMIA FLETTII

ANTERO VAARAMA[1]

While determining a moss collection from Utsjoki, the northernmost part of Finnish Lapland, the present author found a specimen which, without doubt, belongs to *Grimmia torquata* Hornsch. but deviates so much from the normal type in respect to thickness of the walls of leaf cells and to some extent also in a number of other characters that it gave an impetus to study somewhat more extensively the range of variation of characters in this species.

Loeske, in his Grimmiaceae monograph (1913), pointed out that the variability in form and size of leaf cells in *G. torquata* is considerable. Also the sinuosity of cell walls is often subject to variation. The normal sequence of cells in the leaf of *G. torquata,* which normally begins with elongated cells at the base and continues through a rather narrow shortening zone to rounded-quadrate or square cells in the upper part of the leaf, is sometimes disturbed so that elongated cells are almost lacking at the base and are substituted by quadrate cells. According to Loeske, this type of variation is especially likely to occur in high-alpine habitats.

A number of species separated by Kindberg from the *Grimmia torquata* type obviously belong to the above-mentioned range of variation. Kindberg's species *G. streptophylla* and *tortifolia* from Norway and C. Müller and Kindberg's *G. prolifera* from North America have been, accordingly, made synonymous with *G. torquata* by Limpricht, Hagen, and Loeske and considered mere modifications of it (*cf.* Loeske, *l.c.,* p. 158).

The specimen from Utsjoki does not belong to this variation type, for the size relations of leaf cells, as compared with the normal type, have remained rather unchanged, but the incrassate-

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ness of cell walls, a striking character of *G. torquata,* has become much weakened or has disappeared, especially in the basal part of the leaf. The nearest equivalent to such a type in the literature is *Grimmia flettii* (Holz.) Holz., which is described in connection with *G. torquata* by Jones (1933, p. 36) in his Grimmiaceae monograph in Grout's *Moss Flora of North America.*

The taxonomic status of *G. flettii* as based on a single, sterile specimen is obscure. It was described by Holzinger (1904) under the name *Rhacomitrium flettii* on the basis of one specimen collected by Professor J. B. Flett in 1897 "near one of the steam jets issuing from a fissure in the side of the rim of the crater at about 14,000 feet elevation near the summit of Mount Rainier, Washington" (Jones, *l.c.*). Holzinger sent a part of the type specimen to Cardot, who, after careful consideration, agreed that a new species was in question but expressed an opinion that the moss belongs to the genus *Grimmia* and is closely related to *G. torquata, prolifera,* and *tortifolia.* This gave rise to Holzinger's later (1905) new combination, *G. flettii.*

Holzinger's description of the species was as follows: "Stems densely caespitose, radiculose at base, simple or fasciculately branched; color of plants yellowish brown; leaves divergent, then ascending when moist, lanceolate, margin entire; costa reaching apex; cells at base pellucid, thin-walled, with a row of more pellucid, smaller, roundish cells along the margin and this bistratose toward the apex. Entirely sterile."

Through the kindness of Dr. George N. Jones I had for necessary comparisons on loan Holzinger's type specimen of *G. flettii,* which is preserved in the herbarium of the University of Illinois.

Holzinger's note (1904) that "in appearance, color and branching it looks like a diminutive form of *Rhacomitrium ellipticum*" led first to a comparison with this species. In spite of certain similarities in appearance, the microscopic study of a number of *R. ellipticum* specimens, collected from the western coast of Norway and from Scotland (in the herbarium of the University of Helsinki), showed such fundamental differences in the structure of areolation that connecting *G. flettii* with this species seems impossible.

The essential result of the comparison between *G. flettii* and the normal and deviating types of *G. torquata* from Fennoscandia is presented in figures 1-3. The variation of the incrassateness of cell walls is pictured in a series of leaf cell structures beginning from typical *G. torquata* to *G. flettii* (*fig.* 1). The variation is most significant in the basal leaf cells, but a piece of areolation from about the middle of the lamina has also been drawn for comparison (*fig.*

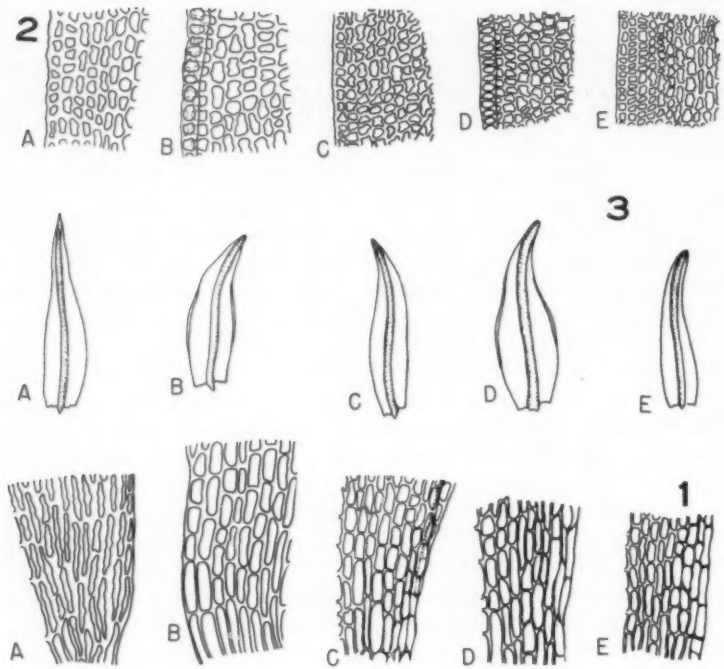

FIG. 1. Areolation of leaf base. *A*, typical *Grimmia torquata*; *B*, intermediate type; *C*, *G. torquata* var. *flettii* from Kuorboaivi; *D*, the same from Kohmelokuru; *E*, type specimen of *G. flettii* from Mt. Rainier. (× 300.) FIG. 2. Areolation from about the middle of the lamina from the same material as in fig. 1. (× 280.) FIG. 3. Leaf of an average type from the same material as in fig. 1. (× 38.)

2). In addition, the shape of an average leaf is drawn from each type (*fig.* 3).

A comparison of leaf cell structure of *G. flettii* and the two most deviating *G. torquata* specimens from Fennoscandia (the first from the fjeld Kuorboaivi in Utsjoki, Finnish Lapland, and the second from canyon cliffs of Kohmelokuru in the former Finnish Arctic Sea district, Petsamo) indicates so close a similarity that they, in my opinion, may be considered one and the same taxon. The cell size in the upper part of the lamina, especially in its marginal zone, is, it is true, smaller than in the type specimen of *G. flettii*. This character is, however, rather variable, and a *flettii*-like areolation has been encountered in a few specimens from Fennoscandia representing intermediates between typical *G. torquata* and its *flettii*-type.

The general appearance, color, and branching of the stem of the specimen from Kohmelokuru is closely similar to that of *G. flettii*. The specimen from Kuorboaivi is different; its stem tops are yellow and the inner part of the cushion blackish-brown as is typical for *G. torquata* growing in exposed habitats. Differences in this respect are obviously subject to modification. The specimen from Kohmelokuru was collected from a shadowy cliff crevice with constantly rather humid atmosphere. The habitat of the *flettii*-type, according to the Flett's note, is most likely also characterized by constant humidity caused by the nearby volcanic steam jet. The Kuorboaivi specimen was collected from a rocky, dry, and exposed locality on a barren fjeld summit. Different degrees of air humidity and exposure seem, on the other hand, not to have any clearly distinguishable modifying effect on the thickness of leaf cell walls.

The type specimen of *G. flettii* is totally devoid of the gemmae characteristic of *G. torquata*. The specimen from Kuorboaivi has developed numerous gemmae but the Kohmelokuru specimen only a few. Variation in this respect is great in *G. torquata*, and the abundance of gemmae is probably, at least to a certain extent, correlated with the air humidity of the habitat in such a way that dryness enhances their development.

The leaf apex of *G. flettii* and the two specimens from Lapland are characterized by the absence or very poor development of the hyaline hair point which, although short, is typical for *G. torquata*. This gives rise to a certain degree of bluntness of the leaf apex which is characteristic of the *flettii*-type. It seems also that the growth of stems in the *flettii*-type is either limited or slower than in a typical *G. torquata*. The tufts of the *flettii*-type seem to remain low, their height being 0.5-2 cm. The screw-like arrangement of leaves in dry condition around the stem—one of the most striking characteristics of *G. torquata*—is either lacking or poorly developed in the *flettii*-type. This is probably caused by the difference in the incrassateness of the basal leaf cells. Also the transparent yellow color of cell walls so typical of *G. torquata* when the leaves are viewed under a microscope is not conspicuous in the *flettii*-type.

From a taxonomic point of view it is interesting that intergrading types occur between typical *G. torquata* and the *flettii*-type. Among the *G. torquata* material preserved in the herbarium of the University of Turku, I have found intermediates from the following localities:

FINLAND: Ostrobotnia borealis, Alatornio, Varavaara-hill, in a cavity of a dolomite cliff, *A. V. Auer*, 1937 (entirely devoid of gemmae); Kuusamo, Kuusamo, Lake Ylimmäinen Tuohilampi, in a crevice of a cliff in the

hill Karjanvaara, *A. V. Auer*, 1937; Lapponia Enontekiensis, Enontekiö, Kilpisjärvi, *J. P. Norrlin*, 1867; Lapponia Inarensis, Utsjoki, in a crevice on the cliff Kenespahta, *Niina Tarén*, 1958. SWEDEN: Jämtland, Storlien, *Sigfrid Medelius*, 1918.

The localities of intermediates are, according to present knowledge, limited to northern Finland and Swedish mountains. It is probable that this form has a scattered occurrence in the northern part of the area of *G. torquata*.

Tufts of the intermediates investigated have been similar to those in the *flettii*-type. They are low, and the twisting of dry leaves is not so regular as in typical *G. torquata*. In all specimens studied only a part of the leaves of one shoot have been intermediate while the structure of the rest is identical with that of *G. torquata*. The number of intermediate leaves varies in different shoots, and the structural intergradation is not correlated with the age of the leaf. As shown by figure 1, the thickness of cell walls is between *G. torquata* and the *flettii*-type. It seems that the occurrence of the intermediate type is not bound to any particular type of habitat and cannot be considered merely an environmental modification.

On the basis of the observations made it seems evident that *G. flettii* belongs as an extreme member to the variation range of *G. torquata* and is connected with it through intermediate types. *G. flettii* cannot thus maintain its rank as an independent species. A question rises about its real taxonomic value. The key character of the *flettii*-type, the thin-walled areolation of the leaf base, seems to be predominantly genotypically controlled in the *flettii*-type, as well as in the intermediates. The *flettii*-type of areolation seems to occur in an intermediate form sporadically in the *G. torquata*-population of northern Fennoscandia. In certain cases the expression of the character may be total, *i.e.*, it occurs typically developed in every leaf of the stem, as in the type specimen of *G. flettii* from Mt. Rainier and the two specimens investigated from the Fennoscandian Arctic Sea region. The obviously strong genotypic control of the key character renders it, in my opinion, possible to consider the specimens representing the *flettii*-type as a separate taxon under the rank of variety of *G. torquata*.

Grimmia torquata var. **flettii** (Holz.) n. comb. (*Rhacomitrium Flettii* Holz., Bryol. 7: 41, Pl. 5, fig. 1-8. 1904. *Grimmia Flettii* (Holz.) Holz., Bryol. 8: 54. 1905.) TYPE LOCALITY: Near one of the steam jets issuing from a fissure in side of crater, (Mt. Tacoma) Mt. Rainier, Washington, U.S.A., altitude 14,519 ft., *J. B. Flett*, Aug. 10, 1897 (TYPE preserved in ILL). A part of the type has been included in Cardot's herbarium; the place of its preservation is unknown.

Specimens other than the type: U.S.S.R. Petsamo Lapland, Pummanki, on shadowy rock walls of the canyon Kohmelokuru, *A. V. Auer*, July 7, 1932 (preserved in TUR). FINLAND. Lapponia Inarensis, Utsjoki, on stones on the barren summit of the fjeld Kuorboaivi in E. Utsjoki, *P. P. Kallio*, July 19, 1960 (TUR).

The validly published description of Holzinger referred to above fits for the type. On the basis of the two other specimens it is, however, necessary to generalize the description in order to make it valid for the whole range of variation of the var. *flettii*:

Cushions as a rule lower than in *G. torquata* and twisting of leaves in dry state less pronounced. Hyaline hair point of leaves either non-existent or poorly developed. Walls of leaf cells strikingly less incrassate, especially in the basal part of leaf where in its outer edge there is always a patch of areolation with quite thin cell walls. Formation of gemmae varies; they may be totally absent. Forms exist integrating *G. torquata* to the var. *flettii*.

The description of the area of the var. *flettii* remains open pending a more thorough revision of *G. torquata* material. It seems likely, however, that var. *flettii* occurs only in severe arctic or alpine environmental conditions.

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THE GENUS CLADONIA IN EASTERN TENNESSEE AND THE GREAT SMOKY MOUNTAINS. I.

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The lichen flora of Tennessee, despite its relative luxuriance, at least in the eastern portion of the state, has been the subject of

[1] Dept. of Biology, University of Nevada, Reno, Nev. Thanks are due to Dr. A. J. SHARP of the University of Tennessee for the loan of *Cladonia* collections from the area. Dr. HENRY IMSHAUG of Michigan State University has been most co-operative in presenting his opinions about certain difficult forms. Mr. ALBERT S. FRY of the Hydraulic Data Division of the Tennessee Valley Authority and Mr. ROBERT R. DICKSON, State Climatologist of the U. S. Weather Bureau, have been extremely helpful in supplying climatological data on the area. Specimens of Michigan *Cladoniae* identified by Dr. A. W. EVANS for the author have been most useful for comparison with Tennessee material.

very few investigations. HENRY W. RAVENEL appears to have been one of the earliest collectors of *Cladoniae* in the area; Tuckerman (1882) listed *C. squamosa, C. caespiticia,* and *C. caroliniana* from Tennessee, all collected by Ravenel. W. W. CALKINS (1890) succeeded Ravenel as a collector in Tennessee and cited two species, *C. caespiticia* and *C. turgida* (the latter identification is possibly an error), as occurring on "rocks and earth at high elevations." BRUCE FINK (1919) mentioned *C. subcariosa* from Lookout Mountain collected by Calkins. Apparently this was distributed as *C. symphycarpa* Fr. in *Lichenes Boreali Americani,* no. 178, and in Calkin's *North American Lichens,* nos. 85 and 94. Fink (1935) listed *C. caroliniana, C. cariosa* fo. *cribosa, C. corymbosula* (syn. *C. pileolata* Nyl., a Caribbean species; this identification is probably in error) from Lookout Mountain; *C. strepsilis* and *C. subcariosa* are listed from Tennessee with the citation of no specific locale. GUNNAR DEGELIUS (1941), during a two-week excursion, collected in the area of the Great Smoky Mountains National Park. His paper listed 24 species of *Cladonia* from this area; these will be considered individually in succeeding papers. A collection of lichens by A. J. SHARP and others housed in the herbarium of the University of Tennessee was destroyed by the disastrous Morrill Hall fire of 1932.

The author, during a year's sojourn followed by a 2-week foray in the region six years later, succeeded in making collections in all but one of the counties under consideration. FIGURE 1 indicates the extent of lichen collections conducted by other collectors and the author.

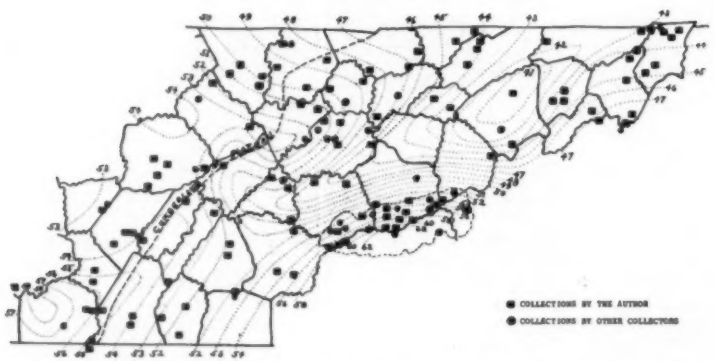

FIG. 1. Eastern Tennessee, showing the extent of collections and the average annual precipitation in inches.

Physiography and Geology

The area under consideration includes 36 counties of eastern Tennessee, extending westward to the western boundaries of Marion, Grundy, Van Buren, Cumberland, Morgan, and Scott counties. The region can be divided into three parallel physiographic provinces, extending roughly in a northeast-southwest direction. Easternmost is the Blue Ridge Province including the highest elevations in the state and consisting essentially of a chain of folded and thrust-faulted mountains termed the "Unakas." The eastern boundary of the state approximates the divide of the highest portion of this series. The Unicoi mountains along the southeastern border extend into Georgia and terminate northeastward at the Great Smoky Mountains, which occupy about 50 miles of the east-central border of the state and in places are 50 miles wide. The main divide in the Great Smoky Mountains is over 5000 feet high for a distance of 36 miles. There are 16 peaks with an elevation over 6000 ft.; the tallest of these is Clingman's Dome, 6642 ft. high. Although this area is the most rugged of the Appalachian system, it is by western standards topographically subdued, exceptional declivities being displayed in only a few areas. Bald, Stone, Roan, and Pond Mountains continue northeastward from the Smoky Mountains along the border of the state to Virginia. The lowest point in the Blue Ridge province is about 800 ft. at the Little Tennessee River. Except for a few coves, the rocks in the Blue Ridge province are nearly all non-calcareous and of metamorphic or sedimentary, Pre-Cambrian origin. Very complex deformation and thrust-faulting is assumed to have taken place chiefly in the Ordovician, the most significant tendency being a trend to a northeast-southwest direction.

To the west and parallel with the Blue Ridge province is the Ridge and Valley Province, varying from 60 miles in width in the north to half that in the south. This series of parallel ridges rises 300 to 800 ft. above the valley floor. The lowest elevation in the valley system is 650 ft., near Chattanooga, and the highest point is the summit of Clinch Mountain, 2500 ft. Predominantly calcareous rocks make up this province, with some shale and sandstone. Cambrian, Ordovician, and Silurian exposures are primarily represented. Devonian rocks are infrequent, and the highest ridges, notably Clinch Mountain, are capped with Mississippian and Pennsylvanian strata. Generally, the ridges are of shale, sandstone, or chert, and the valley bottoms of limestone or dolomite. The western edge of the Ridge and Valley Province is situated along the escarpment of the Appalachian Plateau Province, repre-

sented in Tennessee by the Cumberland Plateau. The dotted line running NE and SW on the map indicates the approximate eastern edge of the plateau. The average elevation at the eastern edge of this plateau is 2000 ft. increasing to a maximum of 3500 ft. toward the northeast.

The plateau is composed essentially of horizontal sandstone and conglomerate strata of Pennsylvanian age. To the south it is deeply dissected by the Sequatchie Valley causing it to resemble an extension of the Ridge and Valley Province.

Climate

Mean temperatures for the area range from 38° to 41° F. during January to 74° to 79° F. during July.[2] Extremes vary from a low of —23° F. in the mountains to a high of 110° F. in the valley bottoms. Precipitation fluctuates from an average of 62 in. in the Clingman's Dome area of the Great Smoky Mountains (with extremes above 85 in.) to an average low of 41 in. in Greene County in the Ridge and Valley Province. The latter region has a maximum average of about 55 in. near Chattanooga. On the Cumberland Plateau precipitation averages about 48 in. in the northeast and 58 in. in Marion County in the South.

Extreme droughts or protracted rainy periods are rare, although some seasonal concentration of precipitation occurs. Within the area of the Tennessee River valley the mean for 18 stations over a period of 24 years indicates that the two months of maximum rainfall are March (5.20 in.) and July (5.56 in.). September and October are the driest months with means of 2.72 and 2.55 in., respectively. Only November, with 3.15 in., of the remaining months has a mean below 4 in.

As might be expected, the Cumberland Plateau has an approximately parallel distribution of precipitation; however, January appears to have the highest mean of 6.11 in. A significant factor apparently affecting lichen distribution within the higher zones of the Great Smoky Mountains is the plethora of localized thunderstorms during the summer, owing to adiabatic cooling of westerly moisture-laden winds and the resultant formation of cumulus thunderheads.

Ecology

The Blue Ridge Province has been categorized as consisting essentially of three formations.[3] The Northern Forest occupies

[2] Climatological data from the Hydraulic Data Division of TVA and from the U. S. Weather Bureau.

[3] Society of American Foresters, Committee of the Southern Appalachian Section, 1926.

areas above 4500 ft. and is characterized by a spruce-fir forest in which *Abies fraseri* and *Picea rubens* form the two dominant associations. The lower elevations in this zone are typified by a *Fagus grandifolia* association.

Between 3000 and 5000 ft. occurs the moist slope and cove forest, including predominantly basswood, buckeye, northern red oak, tulip tree, white pine, and white oak. Within this zone the steeper valleys and north-facing slopes generally possess a hemlock-ravine association. The drier ridges and exposed southern slopes usually have table mountain, pitch, and scrub pine and chestnut, black and scarlet oaks as dominants. Of the three preceding associations, the greatest extent is occupied by the moist slope and cove forest within the Blue Ridge Province.

The Ridge and Valley Province, now largely under cultivation, was apparently characterized originally by a variety of deciduous forest types. North of Knoxville in the district where the parallel ridges are less dissected, the original community seems to have been oak-chestnut. South of Knoxville a transition occurs to an oak-pine community extending into Georgia. Valley floors tend to be dominated by white oak. Lower mountain slopes in the northern zone possess scattered remnants of a beech-white oak community.

The Cumberland Plateau is characterized by pine-oak forests in the drier regions and by oak-pine forests in the moister sites. Relatively wet sites are characterized by oak, red maple, and sour gum.

Lichen distribution in eastern Tennessee with regard to both abundance and variety of species seems to show a direct relationship to the degree of precipitation. The *Cladoniae* appear to be no exception to this generalization, the greatest number of species and *en masse* concentrations occurring in the Smoky Mountains, the region of heaviest precipitation. The genus is scantily represented in predominantly calcareous regions; the most notable exception to this rule is *Cladonia capitata,* which is found frequently on thin soil layers atop exposed limestone or dolomite.

Distribution maps have been prepared for each of the species to be treated in subsequent papers in an attempt to portray the assumed correlations, when they are apparent, between geographic distribution, altitude, and precipitation patterns. Insufficient data, however, prescribes caution in attempting to deduce whether edaphic or climatological factors are of greater significance in the distribution of any individual species.

Systematic Treatment

The genus has been subdivided in accordance with Mattick's (1951) recent classification. Categorization of species has generally followed Evans (1930, 1943, 1947, 1951) with, however, the adoption of the more conservative attitude of Lamb (1951) towards chemical strains. In the absence of any general agreement concerning the parameters of a lichen "species," the way in which these chemical variants are symbolized seems to the author irrelevant to the general attempt to investigate the attributes of each.

Reagents used in the macroscopic color tests were, as follows:

P—alcoholic paraphenylenediamine solution.
K—strong aqueous solution of KOH.
K + Cl—aqueous solution of KOH and $Ca(ClO_2) \cdot 2H_2O$.

Key to Species

In order to make the key as useful as possible, species to be expected in Tennessee but not yet found or reported are included; they are marked with an asterisk (*). Also, for those less inclined to reactionary tendencies than the author, the names of chemical strains previously considered species are enclosed in parentheses.

A. Primary thallus grey, crustaceous, persistent, verruculose. Podetia variable, simple, blunt and cylindrical to irregularly swollen and branched, characteristically brown-tipped when small. Not cup-forming or sorediose. Subgenus Pycnothelia (Ach.) Vain. 1 sp.....*C. papillaria*

A. Primary thallus not apparent, or squamulose; if crustose, then evanescent. Subgenus Eucladonia (Eschio.) Mattick.....B

Subgenus Eucladonia (Eschio.) Mattick

B. Primary thallus usually persistent. Podetia unbranched or not extensively branched and with closed axils (with one exception, *C. leporina*, characterized by red apothecia), cupless or cup-forming. Cups, if present, closed by imperforate membranes. Section Clausae Koerb. C

B. Primary thallus persistent or evanescent. Podetia varying from simple to very extensively branched with frequently open axils. Cup-forming species with open cups or closed by a perforate membrane. (Two species possess sessile or nearly sessile apothecia on the primary squamules). Section Perviae (Fr.) Mattick.....N

Section Clausae Koerb.

C. Apothecia red. Subsection Cocciferae Del.....G

C. Apothecia brown or pale flesh-colored.....D

D. Primary squamules large, persistent. Podetia simple, occasionally cup-forming. Apothecia usually lacking. Subsection Foliosae Bagl. & Carest. 1 sp.....*C. strepsilis* (turns green with the K + Cl test)

D. Not as above .....E

E. Podetia and squamules stramineous; squamules small. Apothecia pale flesh-colored; usnic acid present. Subsection OCHROLEUCAE Fr.....K
E. Primary squamules not stramineous, squamules middle-sized to large. Apothecia not as above. Usnic acid present or absent.....F

F. Podetia cupless, simple to sparingly branched, usually with apothecia. Subsection PODOSTELIDES (Walbr.) Vain. L

F. Podetia usually cup-bearing, occasionally cupless, then simple or sparingly branched, frequently with sterile apices. Subsection THALLOSTELIDES Vain. .....M

Subsection COCCIFERAE Del.

G. Usnic acid absent; podetia and squamules glauescent, but not tinged with yellow. Series SUBGLAUCESCENTES Vain. I
G. Usnic acid present, podetia and squamules tinged with yellow.....H

H. Podetia considerably branched in an intricate fashion. Series LEPORINAE Evans. 1 sp. .....C. *leporina**
H. Podetia simple or branched, but not in an intricate fashion. Series STRAMINEOFLAVIDAE Vain. .....J

Series SUBGLAUCESCENTES Vain.

I. Primary squamules sorediose; older podetia opaque, not generally cartilaginous in appearance 1
I. Primary squamules esorediose; older podetia with brownish, cartilaginous layer exposed 4

1. K+, P+ 2
1. K—, P— 3

2. Irregular pointed projections from margins of cups, yellowish green .....*C. digitata*
2. Cupless, not yellowish green .....*C. macilenta*

3. Podetia usually corticate only basally, farinose-sorediate...*C. bacillaris*
3. Podetia largely corticate, or ecorticate in upper part except for a ring of cortex below the apothecium, occasionally granular-sorediate .....*C. floerkeana*

4. Thamnolic acid absent; K—, P—; didymic, barbatic acids present .....*C. didyma*
4. Thamnolic acid present; K+, P+, didymic, barbatic acids present.... *C. didyma,* thamnolic acid strain (*C. vulcanica*)

Series STRAMINEOFLAVIDAE Vain.

J. Podetia cup-forming 1
J. Podetia not cup-forming 2

1. Farinose-sorediate podetia, cups irregular, sides frequently split..... *C. deformis*
1. Granular-sorediate podetia, cups regular, cup margin smooth or with short teeth .....*C. pleurota*

2. Primary squamules farinose-sorediate, becoming a sorediate crust; podetia small, corticate or ecorticate and sorediate, only rarely branched. Larger podetia somewhat lacerate, with an exposed cartilaginous layer.....*C. incrassata*
2. Primary squamules esorediate, podetia larger, not sorediate, occasionally somewhat branched. Larger podetia not lacerate, no cartilaginous layer exposed.....*C. cristatella*

Subsection Ochroleucae Fr.

K. Podetia small, slender, on old wood; containing barbatic and usnic acids ..... *C. botrytes*

K. Podetia stouter, on soil; containing only usnic acid.... *C. piedmontensis*

Subsection Podostelides (Walbr.) Vain.

L. Primary squamules small, almost crustaceous; podetia simple or sparingly branched at the apex, slender; apothecia large, 2 or more times the diameter of the podetium, dark brown to pale flesh-colored; K+ P+ ..... *C. capitata*

L. Primary squamules larger; podetia stouter; branched or unbranched; apothecia not as proportionately large, dark brown to blackish.....1

1. Podetia lacerated; K+, P— ..... *C. cariosa*

1. Podetia continuous or subcontinuous; K— or +, P+ red or yellow ..... *C. subcariosa*[4]

Subsection Thallostelides Vain.

M. Podetia sorediose, cortex absent or of contiguous to dispersed areoles..1

M. Podetia not sorediose, cortex continuous or separated into areoles.....15

1. Cup-forming, with large broad, deep cups 2

1. Without cups or cups narrow relative to the podetial diameter....7

2. Soredia granular 3

2. Soredia farinose 6

3. Lacking grayanic and cryptochlorophaeic acids 4

3. Possessing either grayanic or cryptochlorophaeic acid.....5

4. Lacking fumarprotocetraric acid; P— ..... *C. chlorophaea*

4. Fumarprotocetraric acid present; P+.... *C. chlorophaea,* fumarprotocetraric acid strain.

5. Grayanic acid present, fumarprotocetraric acid present or absent..... *C. chlorophaea,* grayanic acid strain (*C. grayii*)

5. Cryptochlorophaeic acid present, fumarprotocetraric acid present or absent..... *C. chlorophaea,* cryptochlorophaeic acid strain (*C. cryptochlorophaea*)

6. Podetia stout, usually corticate to the base of the cups; K-brown, P+ red ..... *C. conista*

6. Podetia slender, rarely corticate to the base of the cups, cups sometimes lacking; K—, P+ red ..... *C. fimbriata*

7. Cups shallow, podetia granular-sorediate, long, slender, frequently cupless and pointed, sometimes feebly branched; P— or P+ yellow, homosekikaic acid present..... *C. nemoxyna*

7. Not as above; P+ red 8

8. Primary squamules small 9

8. Primary squamules relatively large 11

9. Podetia uniformly opaque, with narrow cups or blunt apices, sorediate, with isidioid bodies sometimes present; grayanic acid present ..... *C. cylindrica*

[4] The following chemical strains have been distinguished: *C. subcariosa*—atronorine absent, norstictic acid present, P + yellow. *C. polycarpia*—atronorine present, norstictic acid sometimes present, P + yellow. *C. clavulifera*—atronorine absent, norstictic acid absent, P + red. *C. brevis*—atronorine absent, norstictic acid absent, P + yellow.

9. Not as above; grayanic acid absent 10

10. Podetia opaque to brownish-translucent in older parts, granular-sorediate or esorediose, occasionally cup-forming, truncate or acute; sometimes with primary squamules broken into a granular-sorediate mass. ..... *C. pityrea*

10. Podetia opaque to translucent, farinose- or granular-sorediate, sometimes with narrow cups, truncate or acute; with characteristic, much dissected primary squamules ..... *C. balfourii*

11. Podetia yellowish green, very rarely branching 12

11. Podetia greyish or brownish, sometimes branching 13

12. Podetial surface uniformly opaque, basal portion corticate, farinose-sorediate above; if cup-forming, then the inner portion of the cups sorediose ..... *C. coniocraea*

12. Similar to above, but the corticate basal area extending farther up the podetium; inner surface of cups, when present, corticate ..... *C. ochrochlora*

13. Podetia corticate for the most part, not mostly sorediate, with scattered areolae above, cup-forming or cupless and sharp-pointed ..... *C. cornuta*

13. Podetia ecorticate for the most part, mostly sorediate, without scattered areolae above, cups various 14

14. Tending to form regular cups, not usually branching .... *C. fimbriata*

14. Sometimes with abortive proliferating cups, frequently branching .... *C. subulata*

15. Podetial cortex warty-areolate; cups deep, goblet-form, not usually proliferating ..... *C. pyxidata*

15. Not as above 16

16. Cups regular, usually in many tiers, proliferating from the center .. 17

16. Cups regular or irregular, or rarely without cups, usually not in many tiers proliferating from margins or center 18

17. Cups expanding gradually, margins thick, smooth or shallowly toothed, apothecia sessile ..... *C. verticillata*

17. Cups expanding abruptly, margins thin, sinuses between teeth deeper, apothecia on short stipes at margins of cups ..... *C. calycantha*

18. Podetia with a distinctly yellowish tint, usually branched; K—, P+ red ..... *C. simulata*[6]

18. Not as above 19

19. Cups more or less regular, proliferating from the margin, or in one depauperate form without cups and more abundantly branching (resembling a stunted, brownish *C. furcata*), lacking black areas between the areoles at base, P+ red ..... *C. gracilis*

19. Not as above 20

20. Older podetia with a tendency to form dark areas between areoles at the base 21

20[5] Not as above; cups very irregular, proliferating from the margin and

[6] Although not properly belonging to this section, and possibly not a *Cladonia*, *C. "linearis"* Evans may key out to this point. *C. linearis* characteristically has very short podetia on elongated, erect, nearly cylindrical squamules.

base; smoothly corticate, relatively short podetia; P+ red..... *C. mateocyatha*

21. Older podetia with black areas between areoles at base, frequently squamulate, esorediate, sometimes cupless; squamules middle-sized.... *C. degenerans*

21. Older podetia with extensive ecorticate areas appearing dark cartilaginous, more typically granular-sorediate, sometimes cupless; smaller primary squamules than most of the THALLOSTELIDES..... *C. pityrea*

Section PERVIAE (Fr.) Mattick

N. Primary thallus crustose or of minute squamules, disappearing; podetia intricately branched; rarely cup-forming, axils or cups open or closed by a membrane.....O

N. Primary thallus of persistent squamules; podetia simple, sparingly to intricately branched; cup-forming or cupless; cups not closed by a membrane. Subsection CHASMARIAE (Ach.) Floerke.....P

O. Primary thallus of minute, evanescent squamules. Podetia sometimes bearing squamules, podetia corticate, usnic acid present. Subsection UNCIALES (Del.) Vain. .....Q

O. Primary thallus crustose, evanescent, very rare. Podetia always lacking squamules, podetial wall without a cortex, some species lacking usnic acid. Subsection CLADINAE (Nyl.) Mattick. .....R

Subsection CHASMARIAE (Ach.) Floerke

P. Podetia short, cupless, cortex disintegrating or granulose sorediate, primary squamules very small, breaking up into a dense granular crust; K + yellow, P + red.....*C. delicata*

P. Not as above; not sorediate 1

1. Podetia present; apothecia not sessile; primary squamules small or middle-sized; K— or +, P— or +; atronorine present or absent....2

1. Podetia absent; apothecia rare, sessile; primary squamules large, pale grey-green, chalky-white beneath, very brittle when dry; K + light yellow, P + red; atronorine present.....*C. apodocarpa*

2. Podetia short, less than 8 mm. 3

2. Podetia relatively tall, more than 8 mm. 4

3. Podetia 3 mm. or less, unbranched, cupless; K—, P + red..... *C. caespiticia*

3. Podetia mostly 5-8 mm. in length, sparingly irregularly branched, sometimes showing rudimentary cups; K + yellow, P + orange to red .....*C. santensis**

4. Cortex disintegrating; P— .....*C. squamosa*

4. Cortex at least subcontinuous; P— or P + red.....5

5. P— .....*C. crispata*

5. P + red 6

6. Podetia slender, abundant polytomous branching, forming corymbose clusters, axils open or closed, mostly cupless; continuous or subcon-continuous cortex with whitish or semi-pellucid lines between the areoles; primary squamules large, not tending to disappear, K+, P+ .....*C. florida*

6. Podetia slender, abundant dichotomous branching, axils open or

closed, cupless; continuously corticate; large primary squamules tending to disappear; K—, P red.....*C. furcata*

Subsection UNCIALES (Del.) Vain.

Q. Inner cartilaginous layer of podetia continuous, axils open or closed; podetial cortex shiny .....*C. uncialis*

Q. Inner cartilaginous layer of podetia forming a network; axils usually closed except for those at the base of fertile branches; podetial cortex dull .....*C. caroliniana*

Subsection CLADINAE (Nyl.) Mattick

R. Podetia P+ 1

R. Podetia P— 3

1. Podetia whitish grey to grey; K + yellow, P +; atronorine present .....*C. rangiferina*

1. Podetia greenish yellow to greenish grey; K—, P+ atronorine absent 2

2. Branching usually polytomous, with whorls of branches surrounding open axils. Ultimate branchlets furcate; usnic acid present..... *C. sylvatica*

2. Branching usually dichotomous, frequently unequally so, and appearing monopodous. Ultimate branchlets straight or feebly curved in several directions .....*C. subtenuis*

3. Podetial surface disintegrating, mostly dichotomously branching, axils usually closed .....*C. impexa*

3. Podetial surface persistent, branching polytomous, with numerous ultimate branchlets, axils open .....*C. mitis*

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FACTORS BREAKING VEGETATIVE DORMANCY IN CERTAIN MOSSES

PAUL M. PATTERSON[1] AND JANE S. BABER

Periodicity in the growth of many mosses is well known to bryologists. The latest description of this was made by Hagerup (1935). As Hagerup pointed out, many temperate zone mosses are vegetatively dormant during the late summer and fall. Sexual reproduction and vegetative growth in many are initiated in early winter to early spring. The experiment described below attempts to ascertain whether day length or low temperature or both are involved in the summer-fall vegetative dormancy.

A random group of mosses was first collected and planted on sand overlying peat in the college greenhouse during the middle and last part of October 1960, before the weather had cooled to the point of frost. The plants were placed on a bench and illuminated by two goose-neck lamps with 75-watt bulbs connected to a time clock so regulated as to supplement light to a 16-hour day. The lamps were straightened and placed outside of the 2×5 foot area they illuminated to reduce their effective heat to a minimum. Duplicates of the above mosses were planted in the same substratum under a bench protected by its position from artificial light in the greenhouse. This bed had a southern exposure and received, during the day, approximately the same amount of sunlight as the other. This bed was exposed to the seasonal day length. The greenhouse is shielded from early morning and late afternoon sun, and it is estimated that the effective day length here varied from approximately eight hours in December to ten in March. The plants at both sites were regularly watered lightly but allowed to become dry between waterings. At the same time, five duplicates of the above mosses were planted in the two sites for testing with a gibberellin.

On January 11, 1961, duplicates of most of the above mosses were gathered again and planted alongside the former specimens at the two sites. These had been exposed to an effective period of frost or freezing for about 50 days. Careful examinations for growth were made with handlens or low power binocular microscope on January 13, March 6, and April 11, 1961.

Three species, *Brotherella tenuirostris, Dicranum scoparium,* and *Haplohymenium triste,* were not collected again in January

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and so are excluded from the experiment. Greenhouse conditions were not suitable to *Polytrichum ohioense,* which gradually died out (as did the hepatic, *Diplophyllum apiculatum*). The experimental species are listed in table 1, below:

	Mosses without Period of Cold		Mosses with 50 Days of Frost	
Day Length	Short	Long	Short	Long
Anomodon attenuatus	—	—	—	—
A. rostratus	very little	very little	fair	very little
Hedwigia ciliata	1-2 mm.	1-2 mm.	—	—
Aulacomnium heterostichum	—	—	2-5 mm. young sporophytes sparse	1-2 mm. no young sporophytes
Calliergonella schreberi	—	—	about 2 mm.	about 2 mm.
Cirriphyllum boscii	very slight	—	2-5 mm.	1-2 mm.
Hypnum curvifolium	—	—	—	—
Thuidium delicatulum	—	—	some scattered growth	not noticeable
Bartramia pomiformis	—	—	young sporophytes matured	—

New growth on mosses is easily seen in most species because of a lighter green color. However this is not apparent in some species, such as *Anomodon attenuatus, Calliergonella schreberi, Cirriphyllum boscii,* and *Hypnum curvifolium,* and errors as to the amount of new growth can be made easily. A second difficulty arises when the plants are collected with the new growth already initiated, as in some species collected in January, namely, *Anomodon rostratus, Aulacomnium heterostichum,* and *Thuidium delicatulum.* The amount of additional growth must be ascertained. A third difficulty arises when different mosses from different microhabitats are grown under identical conditions resulting in retardation or inhibition of growth to varying degrees.

The first collection of *Hedwigia* grew under both day lengths (without a previous cold period), indicating a neutral reaction to both day length and cold period. *Anomodon attenuatus* and *Hyp-*

num curvifolium showed no discernible growth under any of the conditions; this leads us to suspect that the greenhouse habitat was unsuitable for their growth. *Calliergonella schreberi* collected only in January grew equally well in both situations, thus apparently neutral to day length. All the other species showed growth only after a cold period, and this growth was distinctly better under short-day conditions. The most striking instance was that of *Bartramia pomiformis*. Collected on January 11, it had needle-shaped sporophytes about 1/2-2/3 mature length, and the capsules had not started to enlarge. Plants placed under short-day conditions rapidly matured and shed spores, while those under long days were held dormant, and the sporophytes ultimately died.

Mosses were brought in in October and placed under long and short days and treated with a gibberellin. The gibberellin was obtained from Nutritional Biochemicals Corporation of Cleveland, Ohio, and consisted of 75% K-salt and 25% gibberellic acid (presumably, G3). Water solutions were made, and since the acid is quite insoluble, concentrations were calculated for the K-salt. 100 and 500 p.p.m. were sprayed on different specimens without noticeable acceleration of growth by the stronger solution. The following mosses were tested: *Anomodon attenuatus, A. rostratus, Campylium chrysophyllum, Cirriphyllum boscii,* and *Hypnum curvifolium.* Controls were duplicates collected at the same time for the previous experiment, except for *Campylium,* an accidental in one of the above collections.

Three applications of K-gibberellate were made: November 9 and 30, 1960, and January 4, 1961. The experiment was terminated on January 13. No specified amount of the gibberellate solution was placed on the mosses; they were wetted each time to their capillary capacity. Growth under short days was so slight as to be dubious or lacking, while plants with long days all responded with attenuate terminal growth noticeable even in *A. attenuatus.* Thus K-gibberellate induced growth without cold conditioning under long-day conditions.

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A CONTRIBUTION TO THE ANATOMY OF ACROPORIUM FUSCO-FLAVUM

HANS HÖRMANN[1]

Among the Hawaiian mosses which Otto Degener sends me from time to time, I once found the endemic *Acroporium fusco-flavum* (C.M.) Broth., which is frequent on trees and stumps in moist forests. Its type locality is Molokai (Bartram, 1933, p. 235). *A. fusco-flavum* belongs to the Sematophyllaceae, an essentially tropical family. In Hawaii the family is represented by 15 species in nine genera; among these, 12 species are endemic. On the whole, endemism is very frequent in these old, isolated islands. Of the 197 species included in Bartram's "Manual of Hawaiian Mosses," 113, or more than one-half, are endemics. This is the more surprising because endemism is much less common among mosses than among flowering plants (Herzog, 1926, p. 218), owing to the fact that mosses have fewer differentiating characters and a lesser potential for diverse recombinations of characters. This explains the much rarer mutations, resulting in a much greater stability of species. In Hawaii it is a case of neo-endemism, which is a result of isolation, especially in islands or in high mountains. The so-called "old endemism" does not come into consideration here; it results from the isolation of old types and the dying out of related forms in other parts of the original area of distribution. Old endemics are recognized by phylogenetic isolation as well as by the absence of related forms in the same general area. The genus *Acroporium* is represented by numerous species in the Indo-Malayan region (Herzog, 1926, p. 169), however, and so only neo-endemism is to be considered here.

The tufts are about 4-5 cm. long, shining yellow-green, and irregularly branched. The specimens sent to me were abundantly fruiting. Many stems bore 4-6 red-brown setae which were completely preserved up to the base of the capsules, but the capsules were broken off and not to be found even in the detritus at the base of the plants. This would not have been remarkable in a single case, but of about 100 setae only three could be found with capsules. One of the capsules was immature and therefore made possible a study of the operculum and the calyptra. The second was mature but had a much damaged peristome. Nevertheless, the structure of the exostome and of the segments of the endostome could be determined; whether or not cilia were present could not be

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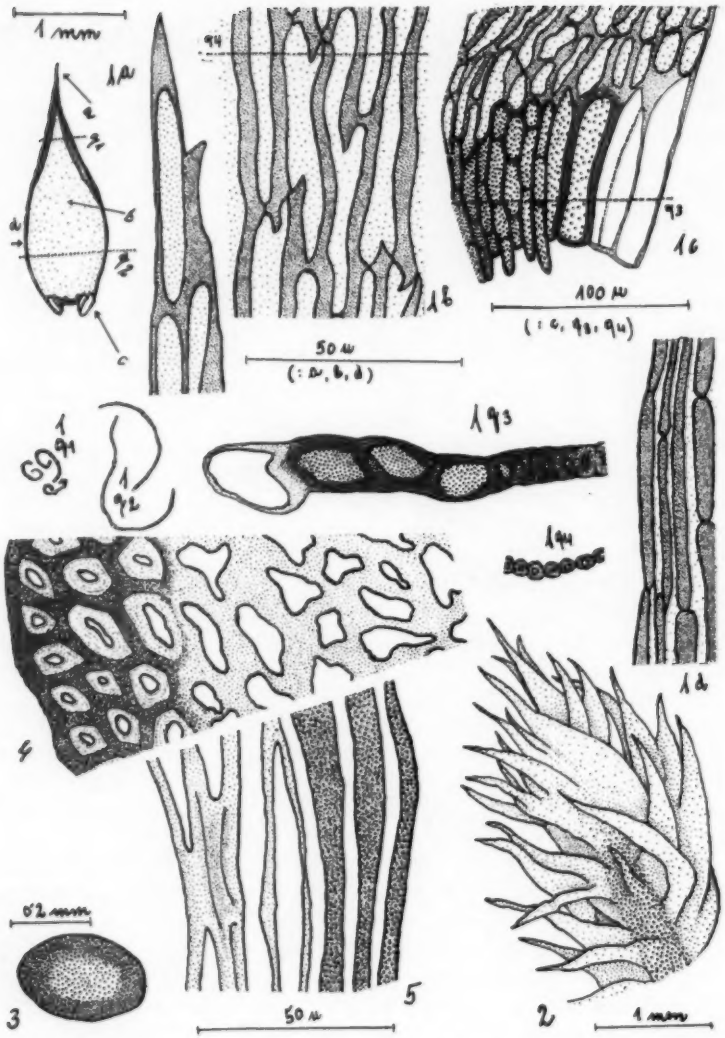

FIG. 1-5. *Acroporium fusco-flavum*. 1. Leaf: *a*, areolation at apex; *b*, areolation at midleaf; *c*, areolation at insertion; *d*, areolation at margin; q_1, cross-section near leaf tip; q_2, cross-section at midleaf; q_3, cross-section of portion of the insertion; q_4, cross-section of a portion of the midleaf. 2. Aspect of leaves when dry. 3. Cross-section of stem, schematic. 4. Portion of stem in cross-section, enlarged. 5. Portion of stem in longitudinal section.

decided. In the third capsule the peristome was represented by only a few fragments, and even the exothecial cells were already falling to pieces. This capsule was still filled with spores most of which had already germinated to form short protonemata. The fact that the setae were intact but the capsules were lacking motivated an anatomical investigation to determine whether there was a preformed zone of abscission.

First of all, the leaf should be discussed. Aside from a slightly different size, there is no difference between the stem and branch leaves. They are closely imbricated, sometimes indistinctly secund on the branches, scarcely altered on drying (*fig.* 2), and about 2.5 mm. long by 0.8 mm. broad. They are ovate-lanceolate (*fig.* 1), weakly concave at the middle, with margins involute (fig. lq_1, lq_2) above and entire except for the apex which is minutely denticulate (*fig.* 1a). There is no costa. The cells of the upper two-thirds are narrowly linear and slightly vermicular, about 4-5 μ broad and about 10:1; they are smooth with strongly thickened lateral walls which are sinuose, especially at the cell ends. Short processes frequently extending into the cells are particularly notable. The cells at the insertion are golden-brown. The inner alar cells are abruptly enlarged and inflated and also golden-brown; the outer alar cells are conspicuously developed and pale or hyaline.

The perichaetial leaves are differentiated from the vegetative leaves especially by their abruptly acuminate points which are rather sharply toothed. The size differences are considerable; the inner perichaetial leaves reach 2.5 mm. in length, but the outer ones measure only about 0.67 mm. (*fig.* 6 and 9).

The stem, elliptic in cross-section, measures about 0.4 mm. in its longer diameter. There is no central strand. The red-brown cortex consists of three rows of very thick-walled cells. The lumina are very small (mostly less than 5 μ); each one is surrounded by a bright, strongly refractive layer. The bright-yellow medullary tissue is also very thick-walled but lax in appearance because of large lumina (*fig.* 3 and 4). The cells of both the cortical and medullary tissues are about 100-150 μ in length (*fig.* 5).

The setae, arising laterally on the stems, are 4-6 mm. long (*fig.* 6), or up to 7 mm., according to Bartram (1933). Young setae are purplish-red, but they become red-brown on maturity. At the base, where the perichaetial leaves are attached, there is a slight thickening, the lower end of which is sparsely rhizoidous. The cross-sections shown in figures 11 and 12 came from the middle portion of the seta. The red-brown cortex consists of two layers of cells with thick walls but relatively large lumina. The bright-yellow medulla is somewhat more delicate but does not differ

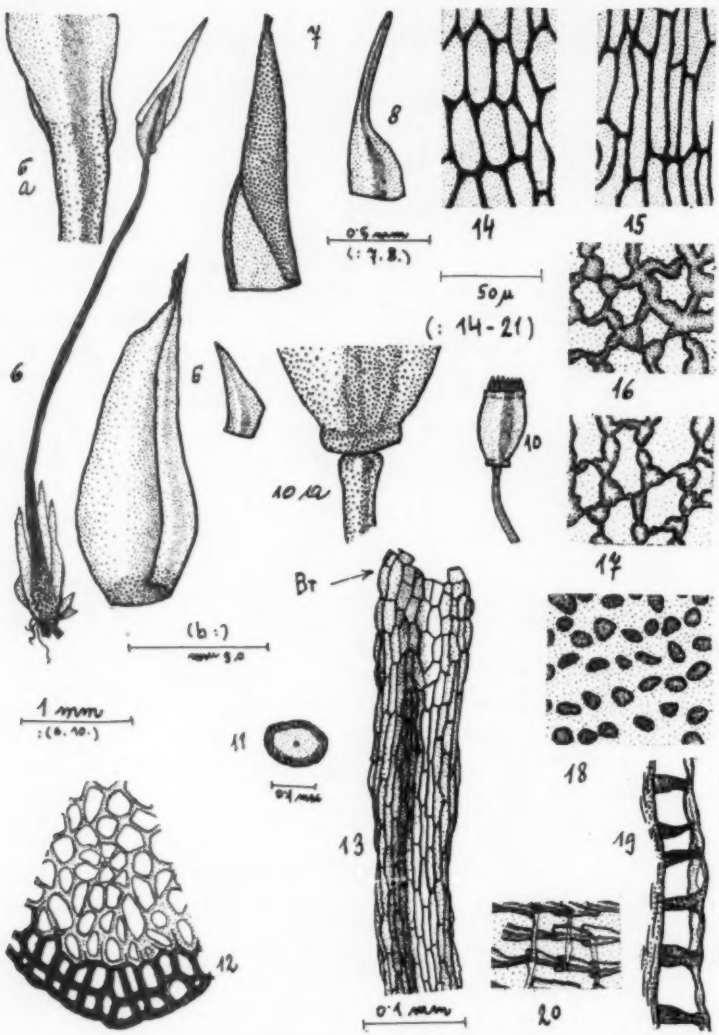

FIG. 6-20. *Acroporium fusco-flavum*. 6. Immature capsule with calyptra, seta, and perichaetial leaves; *a*, base of capsule. 7. Calyptra. 8. Operculum. 9. Two perichaetial leaves. 10. Mature capsule with peristome; *a*, base of capsule. 11. Cross-section of seta, schematic. 12. Portion of seta in cross-section, enlarged. 13. Cells of the seta in surface view; *br*, cells at the abscission zone. 14. Cells of abscission zone at tip of seta. 15. Cells of the remaining portion of the seta. 16. Exothecial cells as viewed from outside. 17. Exothecial cells as viewed from inside. 18. Exothecial cells as viewed from inside at a higher optical plane. 19. Exothecial cells in side view. 20. Exothecial cells in oblique view.

greatly from the cortex in cell size or wall thickness. A small central strand consisting of only a few cells is present. The base of the capsule is interesting. The transition from seta to capsule is gradual except for a strumose swelling visible in younger stages. This swelling constricts as the capsule matures and eventually forms an abrupt zone of transition where abscission occurs at the slightest provocation (*fig.* 10). Fracture is encouraged by the fact that the tissue of the seta is much more spongy and consists of larger cells in this area. The cortical cells along the seta average 8×60 μ in surface view, whereas those at the junction of capsule and seta measure 12×30 μ (*fig.* 15 and 16). The difference in structure is clearly demonstrated in the general view of the seta shown in figure 13.

The calyptra and lid were observed on a single unripe capsule. The cucullate calyptra, split on one side, extends to the middle of the capsule (*fig.* 6 and 7). The operculum is scarcely 1 mm. high, with the slender beak taking up about one-half of its height (*fig.* 8). The red-brown urn is ovoid-cylindric, 0.7 mm. high and 0.4 mm. broad. The peristome is double. The 16 teeth of the exostome are chrome-yellow; the basal membrane and segments of the endostome are pale yellow (*fig.* 22). The detailed structure of the teeth differs greatly on the two surfaces. They are densely cross-striolate on the outer side; on greater magnification the striations can be resolved into rows of papillae resembling a string of beads. A rather broad furrow runs up the middle of the tooth on the outer side; there is no median zigzag line, as in many mosses. A brighter margin is clearly visible. On the inner side the teeth are smooth and distinctly articulated; at lower magnifications the articulations are visible from the outer surface as well. (The front side is undivided except for the surface striations already mentioned; *fig.* 23 and 24.) The segments were unfortunately only partly preserved. According to Bartram (1933, p. 235), they are longer than the teeth. The pale segments of the inner peristome are keeled and narrowly fenestrate along the median line and have delicate, scattered papillae sometimes joined together by shallow depressions (*fig.* 25). There is no annulus.

The spherical spores are brownish, minutely papillose, about 20-34 μ in diameter (averaging 31 μ). The protonema is composed of oblong-cylindric cells. Germination begins with a single filament sometimes followed by a second filament on the opposite side of the spore (*fig.* 21; see Janzen, 1912, p. 58).

In conclusion, I wish to thank Mr. Otto Degener for making the material available for study. The specimen on which this paper was based can be cited as follows: *Eucalyptus* woods, Pupu-

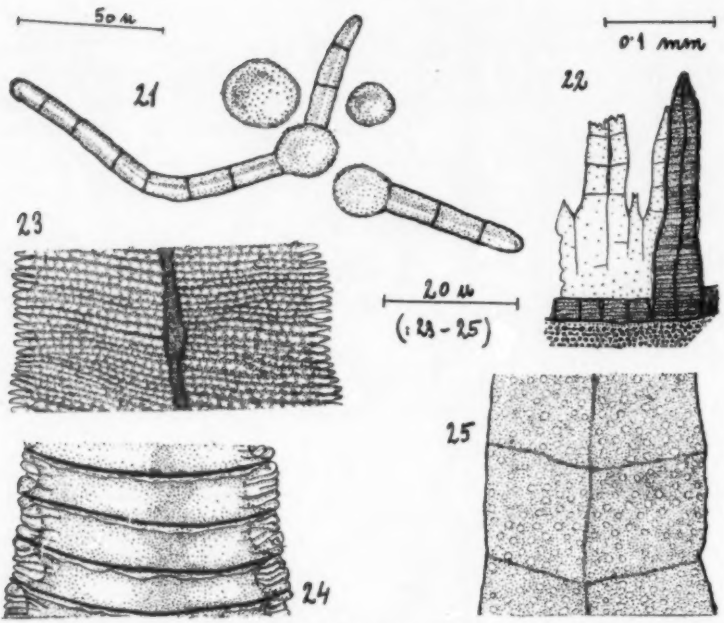

FIG. 21-25. *Acroporium fusco-flavum.* 21. Spores, two of them germinating. 22. Portion of peristome, the segments broken. 23. Structure of exostome tooth, outer view. 24. Structure of exostome tooth, inner view. 25. Structure of endostome segment.

kea, Oahu, *Otto* & *Isa Degener* 27,086, Sept. 1960. (The collection was made possible by financial assistance from the U. S. National Science Foundation.)

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A NEW FISSIDENS FROM LOUISIANA

HOWARD CRUM AND LEWIS E. ANDERSON[1]

Recently, in a contribution to the bryology of Florida (Bryol. 63:32-46. 1960), we described a very distinctive species of *Fissidens*, section SEMILIMBIDIUM, as *F. reesei*. It was then known from two collections from Glades County and one from Polk County. Since that time WILLIAM D. REESE has sent us a specimen from Louisiana (Terrebonne Parish, *Reese* 2589). In his letter, Dr. Reese stated that "the species is not at all uncommon in cypress swamps from Florida right on into east Texas!"

While reviewing the eastern North American species of Fissidens recently, we came across an undescribed species of *Fissidens* closely related to *F. reesei*, collected in Louisiana by LEO F. KOCH. Its characters are not particularly striking, but we decided after lengthy debate that its differences from *F. reesei* are numerous enough to warrant description as a new species.

Fissidens (SEMILIMBIDIUM) **kochii** n. sp.—Plants small, dull green. Stems simple or forked, 1.5-3.5 mm. high. Leaves in 6-10 pairs, somewhat curved at the tips when dry, 1-1.5 mm. long, oblong-lingulate, broadly acute or obtuse, apiculate, evenly serrulate; vaginant laminae bordered nearly their entire lengths by 2-3 rows of linear cells; dorsal lamina usually abruptly narrowed at the base; costa pellucid, ending 2-3 cells below the apex of the leaf; cells 7-10 μ, hexagonal, rather thin-walled, bearing on both surfaces a single, small, central papilla. Autoicous; male buds single, produced near the base of the stem. Setae terminal, 2.3-5 mm. long, yellow, flexuose, often bent at base; capsule about 0.5 mm. long, erect and symmetric; annulus of 1-2 rows of small, persistent cells; operculum rostrate, about 0.4 mm. long; peristome teeth finely papillose below, spirally thickened above. Spores 9-11 μ, greenish, smooth or nearly so. Calyptra cucullate, smooth, entire. (*Fig.* 5-9.)

Plantae parvae, 1.5-3.5 mm. altae. Caules simplices vel furcati. Folia in jugis 6-10, siccitate subfalcata, 1-1.5 mm. longitudine, oblongo-lingulata, late acuta vel obtusa, apiculata, aequaliter serrulata; laminae duplicatae fere usque ad apices marginatae; lamina dorsalis plerumque ad basim abrupte attenuata; cellulae hexagonae,

[1] National Museum of Canada, Ottawa; Dept. of Botany, Duke University, N. C.—Grateful acknowledgment is made to the National Science Foundation for research grant G23-222 (to Duke University), which made this study possible.

7-10 μ, minute unipapillosae, parietibus non crassis. Autoicus; perigonia singula, prope basim caulis producta. Seta terminalis, 2.5-3 mm. longa, plus minus flexuosa, prope basim plerumque clinata. Capsula ca. 0.5 mm. longa, erecta, symmetrica; annulus 1-2 seriebus cellularum parvarum compositus, persistens; operculum rostratum, ca. 0.4 mm. longum; dentes peristomii furcati, inferiore dense papillosi, superiore spirale cristati. Sporae 9-11 μ, subvirides, sublaeves. Calyptra cucullata, laevis, basi integra.

LOUISIANA: In crevices and cracks of clay soil in Sarpe Wild Life Refuge, 2 miles east of Highway 61 about 15 miles northwest of New Orleans, St. Charles Parish, *Leo F. Koch* 7657, Oct. 20, 1954 (type *in herb.* National Museum of Canada).

Fissidens kochii is separated from *F. reesei* by a series of small and fairly intangible characters, mostly quantitative in nature. Trivial and unimpressive as they may seem when taken separately, they add up to produce expressions which are obviously different on comparison of specimens. It is quite possible that further collections will provide evidence of intergradation and make possible a reduction to a varietal level. Meanwhile, *F. reesei* (*fig.* 1-6) can be recognized by the following characters: The plants are larger (5-7 mm. high, rather than 1.5-3.5 mm.), usually with more than 10 pairs of leaves. The leaves have a tapered, rather than an abruptly narrowed dorsal lamina. The leaf tip seems much broader and blunter, less because of any difference in angle than because there is no apiculus, or only a suggestion of one. The borders on the vaginant laminae are shorter but broader (3-5 cells wide near the base of upper leaves and extending less than 2/3 the length of the vaginant laminae, rather than 2/3 cells wide and extending nearly to the apex of the vaginant laminae. The costa is usually shorter, ending 2-6 (rather than 2-3) cells below the apex of the leaf. The papillae on the leaf cells are smaller and less conspicuous, and the areolation, perhaps as a result, is less obscure. The numerous axillary antheridial buds found in *F. reesei* may prove to be an inconstant character; the single perigonia of *F. kochii*, produced near the base of the stem, may have some significance, however. Finally, the habitats seem to be significantly different. Of the four collections of *F. reesei* now known, three came from bark at the base of cypress trees at the high-water level, and one came from bark of an exposed root in an oak-*Sabal* swamp, presumably also associated with flood level, in contrast to the clay substrate on which *F. kochii* was found.

The essential differences between the two species are illustrated in the accompanying figures done by MARY LOU FLORIAN, formerly

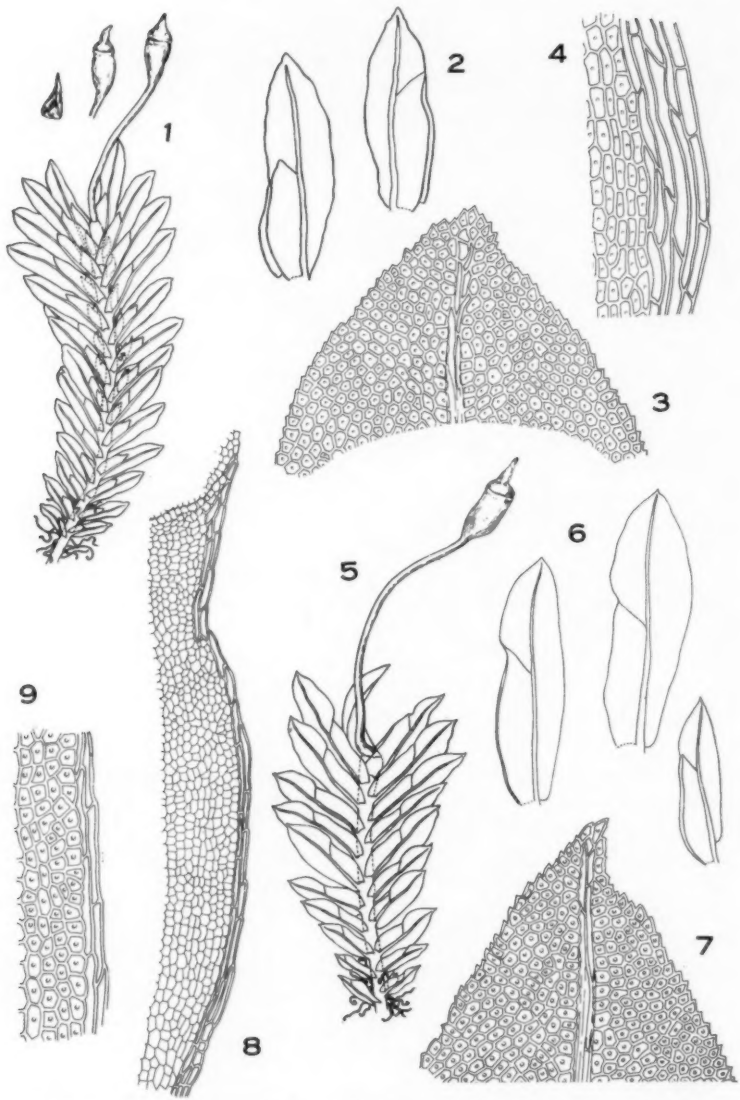

FIG. 1-4. *Fissidens reesei*. 1. Habit; capsule (moist) and calyptra drawn separately, × 11. 2. Leaves, × 31. 3. Cells at leaf tip, × 213. 4. Cells of vaginant lamina at base, × 250. FIG. 5-9. *Fissidens kochii*. 5. Habit, × 11. 6. Leaves, × 31. 7. Cells at leaf tip, × 213. 8. Cells at margin of vaginant lamina (semi-diagrammatically represented), × 138. 9. Cells at margin near apex of vaginant lamina (enlarged), × 250. (*The drawings were done by Mary Lou Florian, with some revision in size by Lynn Bartosch.*)

at the National Museum of Canada. LYNN BARTOSCH has altered some of the sketches in order to make size comparisons possible.

It is a pleasure to name this new species for the collector, Dr. LEO F. KOCH, formerly at Tulane University, as a memento of his bryological activities in the state of Louisiana.

THE GENUS TRIANDROPHYLLUM—SOME NOMENCLATURAL CHANGES

MARGARET FULFORD AND RAYMOND E. HATCHER[1,2]

In a recent paper (Fulford & Hatcher, 1958), the new genus *Triandrophyllum* was described for certain species with a well-defined perianth which previously had been included in the genus *Isotachis*. In that paper (p. 281) the combination *Triandrophyllum antarcticum* (St.) Fulf. & Hatch. based on *Mastigophora antarctica* St. (Bihang Sv. Vet.-akad. Handl. 3, 1900) was inadvertently and incorrectly assigned to the third species. The correct name for this third taxon is **T. georgiense** (St.), based on *Isotachis georgiensis* St. It was correctly illustrated by the figures 26-28, drawn from the type. This species is characterized by its small size and distant, bifid leaves and underleaves with entire margins or with occasional small teeth near the base.

The name *M. antarctica* is a synonym of *T. durum* (St.) Fulf. & Hatch., based on *Herberta dura* St. (1895). However, further study of the collections of Hepaticae at the Conservatoire et Jardin Botanique at Geneva has brought to light additional information concerning this taxon. A collection by Lindig, no. 1722, from Fusagasugá, Colombia, which was described by Gottsche (Ann. Sci. Nat. 5, 1:142. 1864) as "?*Sendtnera trifida* Gottsche," is identical with *Herberta dura*, so that the name for the taxon now becomes **T. trifidum** (G.). Unfortunately, there is considerable confusion in the literature concerning the epithet *Sendtnera trifida* Gottsche. Stephani (Sp. Hep. 3: 670. 1909) included this species in the genus *Isotachis* as "*I. trifida* (G.) Spruce, Hep. A. et A., p. 339," 1885. It is doubtful whether this citation from Spruce is correct, since Spruce (*loc. cit.*), in a footnote, only suggested that

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[2] From work related to a project supported by National Science Foundation Grant G7147. We wish to thank Dr. C. E. B. BONNER for his kind assistance in our work at the Conservatoire et Jardin Botanique, Geneva.

perhaps *Sendtnera trifida* belonged to the genus *Isotachis*. It would seem that the citation should have been *I. trifida* (G.) St. A further point of confusion lies in the fact that Stephani himself later described another species under the name *I. trifida* St. (Sp. Hep. 6: 356. 1922) from plants collected by Spruce in Bolivia. Later, but in the same volume (*op. cit.* p. 572. 1924), Beauverd gave a new name, *I. sprucei* Bvrd. to *I. trifida* St. because of the confusion with the earlier name. The packet of material from Bolivia collected by Spruce in the Stephani Herbarium at Geneva contains no *Isotachis* or *Triandrophyllum*. There is no drawing of *I. trifida* St. in the *Icones Hepaticarum*, and so the nature of this later species could not be verified.

It was pointed out in the earlier paper that the genus *Triandrophyllum* included three species, *T. subtrifidum*, *T. trifidum*, and *T. georgiense*. In brief, the characteristics of the genus are as follows: The plants are small to medium-sized or large (to 7 cm. long), with occasional lateral branches of the *Frullania* type, but more commonly with numerous intercalary branches which may be leafy or flagelliform and are ventral-axillary over one-half the underleaf, or on the stem just above the ventral base of the leaf. The line of leaf insertion is oblique with curved ends. The leaves are incubous, asymmetric, bifid or trifid (rarely quadrifid) to one-third or one-half, with the lateral margins entire or with a few to many teeth or appendages. There is usually an appendage at the junction of the stem and the leaf at both the dorsal and the ventral base. The underleaves are similar to the leaves, symmetric and only a little smaller. The leaf cells are round-quadrate to rectangular in outline and thin-walled with inconspicuous trigones and a faintly to coarsely verruculose to striolate cuticle. The plants are dioicous. Antheridia are borne in the axils of both the male bracts and bracteoles. The female bracts and bracteoles are in two or three series, similar to the leaves and underleaves but with more marginal teeth. The perianth is long, 3-5-plicate and conspicuously contracted above, with the mouth bordered by 6-9 long, triangular segments. One or two branches occur just below the perianth, and these may become floriferous. The unfertilized archegonia remain at the base of the calyptra. The capsule wall is of four or five layers of cells. TYPE SPECIES: *Jungermannia subtrifida* Hook. f. & Tayl., 1844.

Very recently another species has been transferred to the genus by Grolle, whose recent studies on *Acromastigum* have shown that in *A. fernandeziense* S. Arn., antheridia are borne in both the male bracts and bracteoles, the leaf insertion is oblique and curved at

the ends, and the stem in transverse section has one to two rows of smaller, thick-walled cortical cells surrounding the large cells of the medulla. As Grolle pointed out, these are characters of *Triandrophyllum* and not of *Acromastigum*. It differs from the other species of *Triandrophyllum* in the long narrow leaves, bifid to one-fifth or less, the short underleaves, less than half the length of the leaf, and the margin of the underleaf which is spinose-ciliate throughout.

Key to the Species

1. Plants very small, rarely more than 1 cm. in length; leaves and underleaves distant to approximate, bifid to one-half, the margins entire or with a few short teeth near the base.....3. *T. georgiense*
1. Plants 1-5 cm. or more long; leaves and underleaves usually imbricated; leaves bifid or trifid.....2
   2. Leaves divided to ⅓ or ½, ovate; underleaves more than half the length of the leaves 3
      3. Margins of the leaves and underleaves entire or with a few teeth near the base .....1. *T. subtrifidum*
      3. Margins of the leaves and underleaves with numerous often long, sharp teeth, especially in the lower half .....2. *T. trifidum*
   2. Leaves long, narrow, divided only to 1/5 or less; underleaves less than half as long, spinose-ciliate throughout .....4. *T. fernandeziense*

1. *Triandrophyllum subtrifidum* (Hook. f. & Tayl.) Fulf. & Hatch., Bryol. 61(4) : 279. 1958(1959) ; *Jungermannia subtrifida* Hook. f. & Tayl., London Jour. Bot. 3: 579. 1844; *Isotachis subtrifida* (Hook. f. & Tayl.) Mitt. *in* Hook., Bot. Antarct. Voy. 2(2) : 148. 1855; *I. ripensis* Spruce, Trans. Proc. Bot. Soc. Edinb. 15: 339. 1885; *I. anceps* Massal., Nuov. Gior. Bot. Ital. 17: 201. 1885; *I. nordenskjöldii* St., Sp. Hep. 3: 659. 1909; *I. halleana* St., Sv. Vet.-akad. Handl. 46(9) : 69. 1911; *I. lanciloba* St., *op. cit.* p. 70; *I. heterophylla* St., Sp. Hep. 6: 354. 1924; *I. mutabilis* Herz., Arch. Escuela de Farm. Fac. Cienc. Med. Cordoba 7: 26. 1938; *I. ripensis* var. *armata* Rev. Bryol. et Lichén. 11 (1/2) : 24. 1938(1939).—The species has been collected in Guatemala, Costa Rica, Ecuador, Bolivia, Peru, Chile-Patagonia, Tierra del Fuego, Falkland Islands, Tristan da Cunha, Tasmania, and New Zealand.

2. **Triandrophyllum trifidum** (G.) comb. nov.; *?Sendtnera trifida* Gottsche, Ann. Sci. Nat. 5, 1: 142. 1864; *Herberta dura* St., Hedwigia 34: 44. 1895; *Mastigophora antarctica* St., Bihang Sv. Vet.-akad. Handl. 26(6) : 56. 1900; *Isotachis appendiculata* St., Sp. Hep. 3: 659. 1909; *I. trifida* (G.) Spruce *in* St., *op. cit.* 3: 670. 1909[incorrect citation = *I. trifida* (G.) St., non *I. trifida* St., *op. cit.* 6: 356. 1922 = *I. sprucei* Beauverd, *op. cit.* 6: 572. 1924]; *Schisma dura* St., *op. cit.* 4: 21. 1909; *Mastigophora trifida* (G.) St., *op. cit.* 4: 37. 1909; *Lepicolea boliviensis* St., *op. cit.* 6: 362. 1924; *Triandrophyllum durum* (St.) Fulf. & Hatch., Bryol. 61: 279. 1958 (1959); *T. antarcticum* (St.) Fulf. & Hatch., *op. cit.* p. 281, excl. specimens and synonyms.—The species has been collected in Colombia, Bolivia, Chile-Patagonia, and Tierra del Fuego.

3. **Triandrophyllum georgiense** (St.) Fulf. & Hatch., comb. nov.; *Isotachis georgiensis* St., Schwed. Südpolar Exped. 1901-03, 4(1) : 4. 1905; *Herpocladium antarcticum* St., Sv. Vet.-akad. Handl. 49(9) : 66. 1911.—The

species has been collected in South Georgia and Tristan da Cunha (*fide* Arnell).

4. *Triandrophyllum fernandeziense* (S. Arn.) Grolle, Bryol. 64: 25. 1961; *Acromastigum fernandeziense* S. Arn., Ark. Bot. 2, 4(1): 10. 1957.—The species was collected in Juan Fernández: Masatierra, *C.* & *I. Skottsberg,* 209 (S-Pa).

SOME MORPHOLOGICAL CHARACTERISTICS OF THE FEMALE GAMETOPHYTE OF LEPIDOZIA APIAHYNA

JANE TAYLOR[1]

A study of the female gametophyte of *Lepidozia apiahyna* Steph. has revealed morphological features which deviate from those that are commonly accepted as typical of the genus *Lepidozia* Dumort. The position of the female inflorescence and the form of the female bracts and bracteoles are of particular interest in this respect.

In *L. apiahyna* the female inflorescence (*fig.* 1 and 2) is terminal on the main axis while the numerous archegonia are produced by the apical cell and its immediate derivatives. The neck of each archegonium has five vertical rows of cells which surround a row of neck canal cells as commonly found in the Jungermanniales. The unistratose perianth (*fig.* 1 and 2, P) is cylindrical and obtusely trigonous above, with the mouth contracted and ciliate. There are three series of bracts and bracteoles which become progressively more deeply segmented from the outer to the inner series. The segments as shown by those of one of the pair of innermost bracts (*fig.* 3) are laciniate with an "antlered" furcation pattern.

The genus *Lepidozia* is characterized by the presence of the female inflorescence on specialized ventral branches which are intercalary in origin and arise in the axils of the underleaves. In contrast to this, the situation in *L. apiahyna,* as described above, is similar to that found in two related genera, namely *Blepharostoma* Dumort. and *Telaranea* (Spruce *ex* P. Sydow) Schiffn. In the latter genus, however, the female inflorescence may be either terminal or intercalary in origin, even within a species, as in *Telaranea sejuncta* (Ångstr.) S. Arn. Furthermore, both of these genera possess characteristic "antlered" female bracts and bracteoles.

[1] Grateful acknowledgment is made to the Dept. of Scientific and Industrial Research, New Zealand, for a National Research Fellowship which has enabled the writer to carry out this work at the Botany Division, Christchurch.

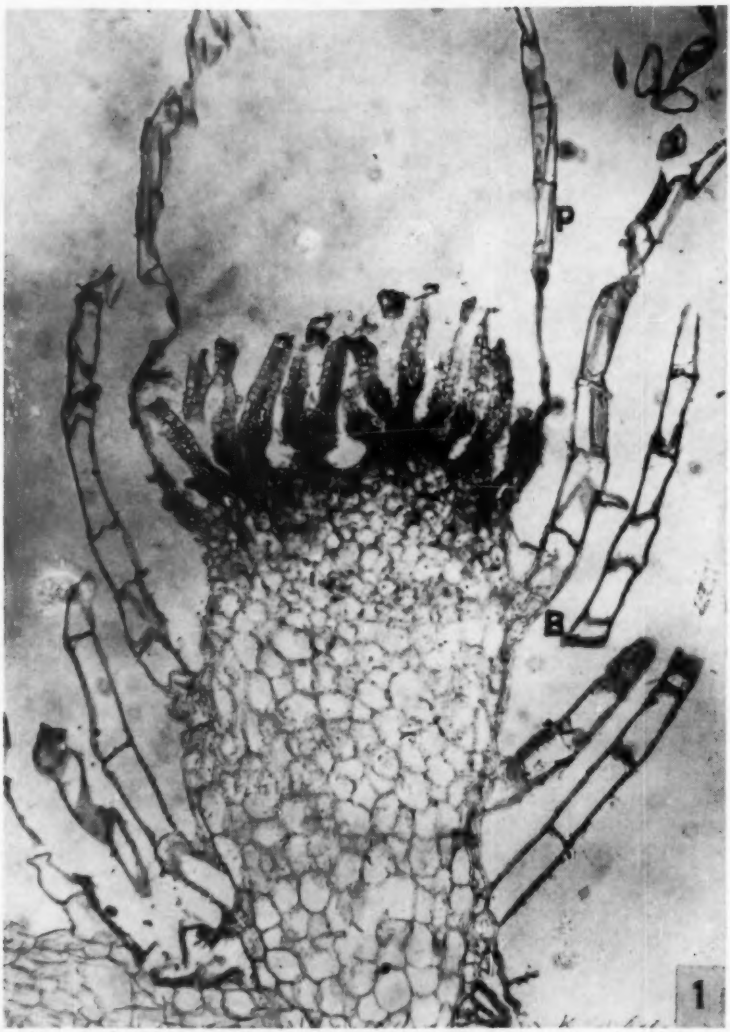

FIG. 1. *Lepidozia apiahyna*. Photomicrograph of a median longitudinal section through the female inflorescence, × 100: P, perianth; B, a bract of the innermost series.

In *Lepidozia apiahyna*, the presence of ventral intercalary branching, regular bipinnate, terminal *Frullania* type of branching, the structure of the cells of the quadrifid leaves (*fig.* 4) and underleaves (*fig.* 5), and the anatomy of the stem as seen in transverse

section (*fig.* 6 and 7) with a unistratose cortex of about 14 rows of cells surrounding a medullary core of numerous rows of smaller cells suggest that the most direct relationship is with *Telaranea.* It is difficult, however, to recognize the diagnostic characters of this genus as distinct from those of *Blepharostoma.*

Schuster (1961) writes, "In several of its characters, *Blepharostoma* admittedly approaches such reduced genera of Lepidoziaceae as *Telaranea* and *Microlepidozia.* However, the setae of the sporophytes, in the latter, are never reduced to 4 inner cell rows (though typically with only 8-10 outer cell rows); the latter groups have at least partially ventral branches, and the female branches are almost always abbreviated and ventral." While these criteria may be valid, their application to species of *Telaranea* is limited. Sporophytes are frequently not available, the female branches are not always abbreviated and ventral, even when present, and ventral branches may be absent. In the case of *Lepidozia apiahyna,* only one of these features can be scored positively.

There is also a lack of agreement among hepaticologists as to the delimitation of the genus *Telaranea.* According to Schuster and Blomquist (1955), "The genus *Telaranea,* of the family Lepidoziaceae, consists, as far as is known, of only two species. . . ." It is evident from the extra-European species cited, that Müller (1912-16) had a much broader concept of the taxon, which he recognized as a subgenus. More recently, in dealing with the European complex, Müller (1956) merged the European species of *Microlepidozia* with *Telaranea* and accorded the latter generic status.

Until more knowledge of the morphological details of the species involved becomes available, the basis for the selection of diagnostic characters, in any attempt to re-define the genus *Telaranea,* must remain in the realm of speculation. The morphological characters of the female gametophyte of *Lepidozia apiahyna,* which may prove to be a species of *Telaranea,* are therefore placed on record.

It is a pleasure to express my thanks to Dr. C. E. B. Bonner for the loan of the type specimen of *Lepidozia apiahyna* from the Stephani Herbarium (G); to Dr. R. E. Hatcher for assistance with the illustrations; and to Mr. A. P. Underhill for the photomicrograph.

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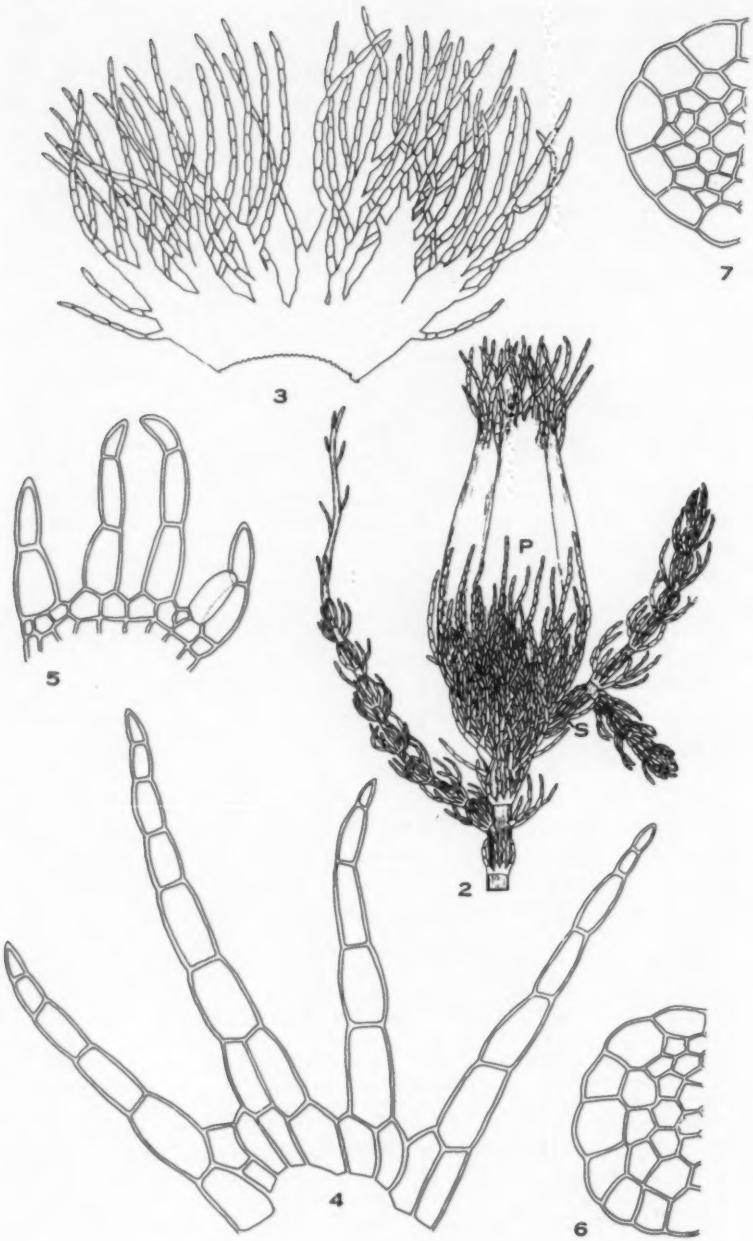
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chaete and *Chandonanthus* subg. Tetralophozia, subg. n. Jour. Hattori Bot. Lab. 23:192-210 (1960.)
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Fig. 2-7. *Lepidozia apiahyna*. 2. Habit sketch of upper portion of stem with female inflorescence, ventral view, × 40: P, perianth; S, branch of the lateral *Frullania* type. 3. Female bract of the inner series, × 80. 4. Stem leaf, × 360. 5. Stem underleaf, × 360. 6, 7. Portions of transverse sections of stem, × 360. *Fig. 1-7 were drawn from a portion of the original material collected by Puiggari in Apiahy, Brazil (G).*

PYLAISIA POLYANTHA

Henry S. Conard[1]

There are three well-defined conditions in *Pylaisia* in North America. 1. Inner peristome completely adherent to outer, *P. intricata* (Hedw.) B. & S. 2. Inner peristome adherent to outer on the lower half only (the basal membrane), the segments being free, *P. selwynii* Kindb. 3. Peristomes entirely free and separate, *P. polyantha* (Hedw.) B. & S., *P. jamesii* Sull. & Lesq., and *P. subdenticulata* B. & S. Of these last three Grout (1932) wrote, "Probably all three would better be regarded as variants of one species." Of *P. subdenticulata* Sullivant (1864) wrote "there may be doubt whether it may not ultimately prove to be only a form" of *P. polyantha*. Mrs. Britton (in Grout, 1896) published *Pylaisiella polyantha* var. *jamesii*. The resulting confusion is shown by many changes of names on labels in herbaria, including my own, and by the fact that specimens labeled by experts usually do not show all of the diagnostic characters of the putative species.

The alleged distinctions between these species and their varieties have to do with (1.) *Shape of leaf*. (2.) *Acumination of leaf*. (3.) *Serrulation of leaf*. (4.) *Number of quadrate alar cells*. (5.) *Size and shape of median cells*. (6.) *Shape of operculum*. (7.) *Cilia of endostome*.

1. Shape of Leaf

P. polyantha in B. & S. (1851) has leaves "late lanceolatis" (*fig.* 1). Grout (1932) wrote "broadly ovate-lanceolate" (*fig.* 2). Grout's *Musci Perf.* 136, as *P. polyantha*, has broadly ovate-lanceolate leaves. *P. filari-acuminata* C.M. & Kindb., placed under synonymy by Grout as *P. polyantha* var. *pseudo-platygyria*

[1] Lake Hamilton, Fla.

(Kindb.) Grout, has lanceolate leaves (*fig.* 3). A wide range of leaf shapes has been accepted within the species. Thus the "ovate to broadly ovate" leaves of *P. jamesii* and the "ovate-lanceolate" leaves of *P. subdenticulata* (Sullivant, 1864; Grout, 1932) are not diagnostic.

2. Acumination

P. polyantha in B. & S. (1851) has leaves "longe acuminatis." Limpricht (1904) included in *P. polyantha* a var. *brevifolia* with leaves "kürzer, besonders kürzer zugespitzt," and a var. *longicuspis* with "Blattspitze fast von Laminalänge, haarförmig verlängt" (*fig.* 5). The range of acumination within the species is very wide. Within that range fall the "rather abrupt acumination of varying length" of *P. jamesii* (Grout, 1932) and the "gradually long acuminate" leaves of *P. subdenticulata* (Grout, 1932). But Sullivant distinguished *P. subdenticulata* by its "shorter pointed leaves."

Typically, however, *P. jamesii* has acute leaves, according to Grout (1932). Of several specimens named *P. jamesii* I have seen acute leaves on a part of one specimen; other leaves on the same sod are rather longly acuminate (*fig.* 6). This is the case with a type specimen borrowed from the Farlow Herbarium. An acute leaf from a specimen labeled *P. subdenticulata* is shown in fig. 7. The acumination is not diagnostic.

3. Serrulation of Leaf

P. polyantha usually has conspicuously entire leaves, but Grout's var. *pseudo-platygyria* (*P. filari-acuminata* C.M. & Kindb.) is "distantly serrate-dentate along sides of acumination," as I also have observed (*fig.* 4). The same is true of the Eurasian var. *longicuspis* Lindb. & Arn. And Grout's var. *brevifolia* Lindb. & Arn. of *P. polyantha* has "the subdenticulate leaves" of *P. subdenticulata*. Slight subdenticulation may be seen on many specimens of *P. polyantha* and its varieties. I have seen only one leaf that was distinctly subdenticulate below the acumen. The margin of the leaf gives no clear distinction between the alleged species.

4. Quadrate Alar Cells

Grout introduced an approach to precision by giving the number of quadrate alar cells along the margin of the leaf, instead of "permultis" (*P. subdenticulata* in Sullivant, 1864) or an "ovale, nicht scharf begrenzte Gruppe" (Limpricht, 1904). Grout wrote, for *P. polyantha* 3 to 9 along the margin, for *P. jamesii* and *P. subdenticulata* 10 to 15. But for *P. polyantha* var. *brevifolia* Grout has "the more numerous quadrate alar cells of *P. subdenticulata*."

My own counts of quadrate alar cells of specimens labeled *P. polyantha* follow: Grout's *Musci Perf.* 136, South Dakota, 7 to 14.–From Austria 6 to 16.—From Hungary 9 to 13.—From Sweden 7 to 10.—From Poland 4 to 9 (fo. *longicuspis*).—From Finland 6 to 15.—From Saskatchewan 4 to 6.—From Alberta 7 to 21.—From Iowa 10 to 16.

It is difficult to make these counts exactly because, as Limpricht wrote, the group of alar cells "sich an den Seitenrändern hinaufzieht und oberwärts einen einzellreihigen Saum (rhomboidischer Zellen) bildet." I have seen a leaf bordered on one side with short rectangular cells nearly to the apex. Some specimens from British Columbia determined by H. Crum as *P. subdenticulata* have strikingly large, dense clusters of alar cells, as the descriptions indicate. Another, also from B.C. and det. H. Crum, has 7, 8, and 12 alar cells on the margin. It seems that plants which must be—and have been—assigned to *P. polyantha* have numbers of quadrate alar cells covering the entire range of this group of species.

5. Size and Shape of Median Cells

The cells of each leaf are so variable in size and shape that I have been unable to verify Grout's figures of 8:1 for *P. polyantha,* 3-6:1 for *P. jamesii,* and 6-8:1 for *P. subdenticulata.* In general narrow-leaved forms have narrow cells, and broad-leaved forms have wide cells.

6. Operculum

There is considerable variation in opercula on *P. polyantha,* even in a single collection (*fig.* 9, 13, 14). I have not seen any as long as shown in Sullivant's plate of *P. subdenticulata* ("longius rostrato"). Two collections from B.C., det. H. Crum, in hb. Duke University, come close to it. But most of the specimens named *subdenticulata* have conical opercula or none at all! It seems that there are all gradations from rounded to conical, conic-apiculate, and conic-rostrate. An abnormal specimen is shown in fig. 13, with a normal one from the same packet.

7. Cilia

For *P. polyantha* Bruch and Schimper have cilia "brevibus, singulis vel binatis." Grout wrote "cilia single, mostly rudimentary." But for the var. *pseudo-platygyria* he wrote "ciiia 1 or 2, better developed than in the type." I find mostly 2 cilia, often 1, rarely 3, always rudimentary.

For *P. subdenticulata* Sullivant wrote "ciliolis subnullis," and Grout wrote "cilia lacking." A specimen in hb. Duke University

annotated by Grout was first marked "*P. polyantha,* very near *subdenticulata;* quadrate alar cells as numerous as in that species, but there are rudimentary cilia, and the whole plant is larger than in *subdenticulata.*" Later the *polyantha* was crossed out, and over it Grout wrote "*subdenticulata*!" Evidently he considered cilia secondary in importance.

A cilium is a remnant of cell walls left after resorption of adjacent cell walls. It is indefinite in shape and margins, but is more or less rounded at the end. It is very fragile. It is the upper end of a row of cell plates that can be traced to the middle or even to the base of the basal membrane (*fig.* 15, 16). According to Sullivant's plate, *P. subdenticulata* has such a row of plates in the basal membrane. The row ends abruptly with a straight line, the edge of a plate. That is not the ending of a resorbed series of cells. It is the place where a fragile, rudimentary cilium was broken off. Grout was right in taking the absence of cilia lightly.

Absence of cilia is a possibility. I have a fragment of endostome from Alberta (*G. H. Turner*) in which the interval between two segments has one cilium, the next interval has two cilia, the next none, and the next none. In these two latter cases there is not even a row of plates in the basal membrane to represent a cilium. This absence of plates also occurs in a specimen from Alaska (*Rhoda Thomas*), whereas another interval has one cilium and another has a row of plates with the cilium broken off. The Alberta specimen I attribute to fo. *polyantha,* the Alaskan to fo. *longicuspis.*

In summary, there remains no reliable basis for more than one species in this maze of forms. *Pylaisia polyantha* is the name of a circumboreal population which is very heterozygous and whose individual members respond morphologically to environmental conditions. The types of *P. jamesii* and *P. subdenticulata* cannot be more than fortuitous combinations of the variable characters of *P. polyantha* in various habitats and microclimates. They have about as much taxonomic significance as red ears in a field of yellow corn (maize).

Since mature opercula are present on the plants, in nature, for only a short period in autumn, and cilia are readily broken and lost after the capsules open, the leaves offer the only satisfactory basis for a classification of the forms, as was recognized by Lindberg & Arnell (1890) for Eurasia.

These authors have admirably expressed the variability of *P. polyantha* as it occurs in northern Siberia, where it is common "in einem grossen Formenreichtum. . . . Es sind besonders die Blätter, die bei dieser Art sehr veränderlich sind. Sie sind am

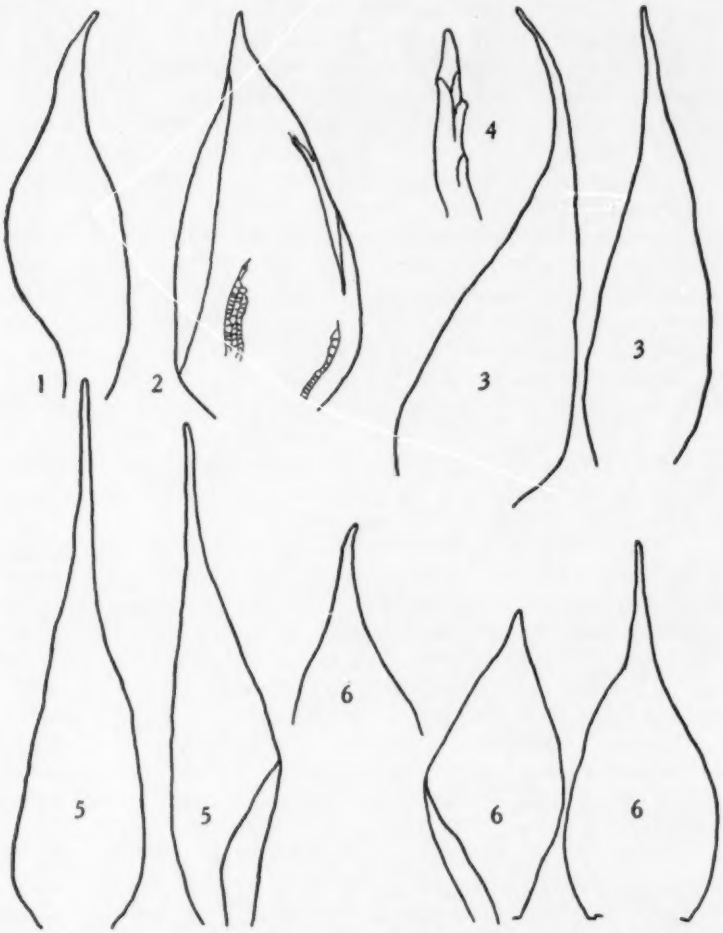

FIG. 1-6. *Pylaisia*. 1. *Pylaisia polyantha* leaf from the *Bryologia Europaea*. 2. Leaf (1 mm. long) from Grout's *Musci Perf.* 136, from South Dakota, as *P. polyantha*—better referred to fo. *jamesii*. 3. *P. polyantha* fo. *longicuspis*, leaves from Nat. Mus. Canada 183/14614, from Quebec, as *P. filari-acuminata*. 4. Leaf apex of same. 5. *P. polyantha* fo. *longicuspis*, labeled *P. polyantha*, from Poland, leaves 1.4 mm. long. 6. *P. jamesii*, leaves from Sullivant & Lesquereux, *Musci Bor. Amer.* Ed. 2. 383, in hb. Farlow.

gewöhnlichsten ein wenig einseitswendig, aber sie können auch allseitig (und dann zuweilen fest angedrückt) oder zweiseitig sein. In ihrer Form sind sie flach oder mehr oder minder konkav; die Breite

wechselt sehr und noch mehr die Länge der Spitze; zuweilen fehlt eine besondere Spitze gänzlich, in welchen Falle eine Zahnung in der oberen Hälfte des Blattes gewöhnlich eintritt: die langgespitzten Blätter sind meistens völlig ganzrandig.... Die Anzahl der quadratischen Zellen in den Blattecken wechselt auch sehr, ebenso wie die Länge der Zellen in den anderen Theilen der Blätter veränderlich ist. In demselben Rasen sind die Blätter häufig sehr vielgestaltet."

Three kinds of leaf can be fairly well distinguished: 1. Ovate-lanceolate and curved upward, on curved, pinnately arranged branches, as in the figure in the *Bryologia Europaea,* Plate 455 (*fig.* 1), which may be taken as the type of *P. polyantha.* 2. Broadly ovate, concave, little or not at all curved, on irregularly arranged branches tending to be terete and not curved. 3. Longly and slenderly acuminate, lanceolate to ovate-lanceolate, mostly curved upward, on curved branches.

These groups can only be separated arbitrarily. The extremes are easily recognized. On the placement of intermediates there will never be complete agreement.

Within these groups are found plants with creeping, loosely matted stems with short, pinnately arranged branches which curl up into a simi-circle when dry; or crowded, prostrate stems; or crowded, erect, branching shoots in dense mats 10 to 15 mm. thick. The leaves may be straight, or more or less curved upward, or, rarely, curved downward (hypnoid); usually entire, but sometimes subdenticulate, or with a few dentations near the apex.

If names are required for the three leaf-groups, we have at hand fo. *polyantha* (which needs no citation of authority) for no. 1. For no. 2 we have fo. **jamesii** (Sull. & Lesq.) stat. nov. (*Pylaisia jamesii* Sull. & Lesq., Musci Bor. Amer. Ed. 2. 383. 1865) if we can ignore other characteristics attributed to *jamesii.* Of *P. jamesii* Grout wrote "sporophyte scarcely to be distinguished from that of P. polyantha." For no. 3 we have fo. **longicuspis** (Lindb. & Arn.) stat. nov. (*Stereodon polyantha* var. *longicuspis* Lindb. & Arn., K. Sv. Vet.-Akad. Handl. 23(10): 152. 1890, again ignoring other characteristics—"foliis in cuspidem laminae aequilongam, piliformem attenuata, margine integro vel levissime serrulato, cellulis angularibus paucioribus" (Lindberg & Arnell, 1890).

Lindberg & Arnell recognized five varieties of *P. polycarpa* (as *Stereodon*), and Limpricht included these in his *Laubmoose* "für Formenliebhaber." It seems best to recognize only three and to rate them as forms.

Grout pointed out that American plants are consistently smaller than their European counterparts: leaves 1 mm. long in North

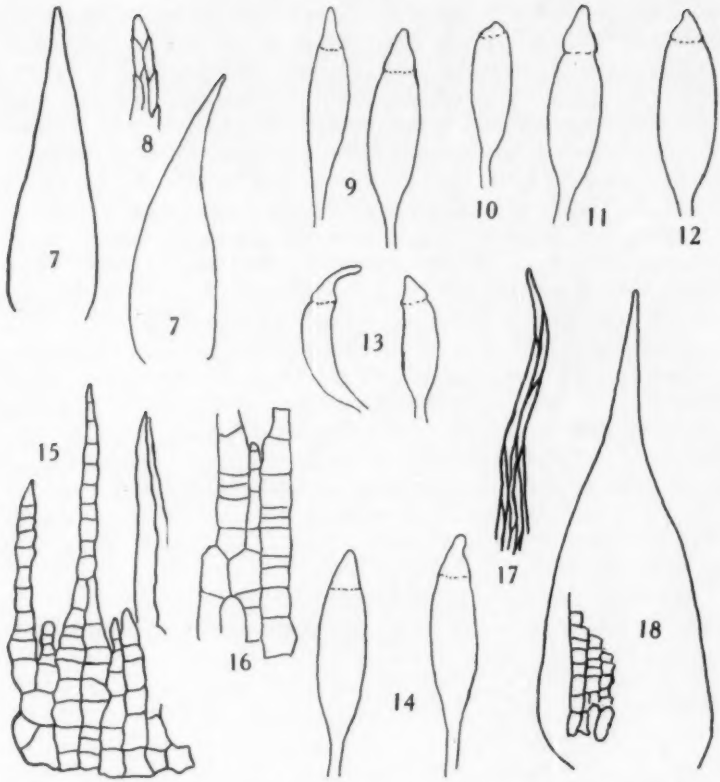

FIG. 7-18. *Pylaisia*. 7. Leaves from a British Columbian specimen labeled *P. subdenticulata*—better referred to *P. polyantha* fo. *polyantha*. 8. Leaf apex of same. 9. Capsules from Poland. 10. Capsule from Owen Sound, Canada, abnormal. 11. *P. polyantha* fo. *longicuspis*, capsule from Nat. Mus. Canada 183/14614, as *P. filari-acuminata*. 12. Capsule from Finland, restored in lactic acid. 13. A normal and an abnormal capsule from one packet, from Iowa. 14. Two capsules from a specimen in hb. Duke Univ. 137438, labeled *P. jamesii*. 15. Endostome from Alberta, *Turner* 9701. 16. Endostome from Alberta, *Turner* 1133. 17. Apex of leaf of *P. suttoni*, from Jennings (1936). 18. Leaf (1.3 mm. long) and alar cells of *P. pseudo-platygyrium*, from Nat. Mus. Canada 906a/4287, presumably the type.

America, 1.5 mm. in Eurasia. That is generally true, but I have leaves 1.4 mm. long from Quebec and South Dakota and 1.6 mm. from Alaska. Apparently our collections are mostly from "continental climates" and those from Europe from more oceanic climates.

What we are seeking is a means of describing precisely the minute details which our observations reveal. The lumping of all of the character-combinations of such a species as *P. polyantha* into three species obscures the facts. It leads to exactly the confusion that has reigned in the treatment of the *polyantha* group. We can approach precision by using one character to separate the groups: shape of leaf. Within these groups we may use descriptive terms for the several characters. Two or more such terms may apply to one specimen, the terms having no taxonomic status. For example: *Color* bright or sordid-green or yellowish. *Stems and branches* repent, caespitose, prostrate, erect. *Leaves* erect, falcate, complanate, imbricate, spreading, hypnoid (bent down), secund (bent upward); lanceolate, ovate; acute, acuminate, filiform-acuminate; entire, subdenticulate, distantly denticulate. *Alar cells* 3 to 20, the numbers given for each specimen. *Operculum* rounded, conic, conic-apiculate, rostrate. Obviously the many combinations of these characters cannot be expressed by a half-dozen taxonomic names, and to propose names for all of them would be absurd. For brevity a series of letters or numbers could be arbitrarily chosen in place of words. The plants can be sorted into as many categories as desired in the herbarium.

In 1936 Professor Jennings described *P. suttoni* from Southampton Island, Hudson Bay. It differs from *P. polyantha* fo. *longicuspis* in that there are no quadrate alar cells. Leaves 0.6 to 1.0 mm. long (*fig.* 17). The type (and only) specimen cannot now be found. Having seen no material I would not attempt to evaluate the species.

In summary, I recognize in North America *Pylaisia polyantha* (Hedw.) B. & S. fo. *polyantha*, fo. *jamesii* (Sull. & Lesq.) emend. et stat. nov., fo. *longicuspis* (Lindb. & Arn.) emend. et stat. nov.

SYNONYMY

Pylaisia polyantha B. & S., 1851.
Leskea polyantha Hedw., 1801.
Stereodon polyanthos (Hedw.) Mitt., 1864.
P. polyantha fo. *polyantha*.
P. heteromalla B. & S., 1843. (*fide* Lesq. & James).
P. polyantha var. *homomalla* Lindb. 1872.
Stereodon polyanthos var. *homomallus* (Lindb.) Lindb. & Arn., 1890.
Pylaisia ontariense C.M. & Kindb. *in* Mac., 1892.
P. pseudo-platygyrium Kindb. *in* Mac., 1892.
P. polyantha var. *pseudo-platygyria* (Kindb.) Grout, 1931.
P. subdenticulata B. & S., 1851.
P. polyantha fo. *jamesii* (Sull. & Lesq.) emend. et stat. nov.
P. jamesii Sull. & Lesq., 1865.
Stereodon polyanthos var. *brevifolius* Lindb. & Arn., 1890.

S. polyanthos var. *subjulaceus* Lindb. & Arn., 1890.
Pylaisiella polyantha var. *jamesii* (Sull. & Lesq.) E. G. Britt. *in* Grout, 1896.
Pylaisia polyantha var. *jamesii* (Sull. & Lesq.) Habeeb, 1950.

P. polyantha fo. *longicuspis* (Lindb. & Arn.) emend. et stat. nov.
Stereodon polyanthos var. *longicuspis* Lindb. & Arn., 1890.
Pylaisia filari-acuminata C.M. & Kindb. *in* Mac., 1892.
?P. suttoni Jenn., 1936.

Acknowledgments

This study was initiated by my attempts to classify the collections of the late Professor B. Shimek of the State University of Iowa, taken in northwestern Iowa. It became imperative in dealing with the 54 collections (72 packets) taken by Mr. M. A. Welsh of Prince Albert in middle and northern Saskatchewan and the foot-square mats sent by Dr. George H. Turner of Fort Saskatchewan, Alberta. Dr. C. D. Bird of Edmonton also submitted 55 packets from Alberta and Saskatchewan. Total of collections seen was 246.

Through the kindness of the responsible officers I was able to borrow presumptive types of *P. pseudo-platygyrium* Kindb. and *P. filari-acuminata* C.M. & Kindb. from the Canadian National Museum. Notes on the type of the last named taxon were kindly furnished by Dr. Herman Persson; he found no type of *P. pseudo-platygyrium*. From the Farlow Herbarium came a type of *P. jamesii* Sull. & Lesq. The Duke University Herbarium lent specimens of *P. jamesii* and *P. subdenticulata*. A photostatic copy of Lindberg & Arnell was promptly supplied by the Farlow Herbarium Library. Dr. O. E. Jennings kindly sent a copy of his description of *P. suttoni*. For all of these favors much thanks.

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MOSS LEAVES IN POLARIZED LIGHT

EDWARD C. TAYLOR, SR.[1]

In a previous paper (Taylor, 1959) I gave an account of the use of the polarizing microscope in the study of the structure of peristome teeth. It is the purpose here to give some applications of this tool to the study of moss leaves. Since, even if not equipped with a polarizing microscope, most readers are probably associated with some institution having a geology department which is equipped with one, I urge them to take some slides of leaves, including several with costas or borders, and get someone familiar with the instrument to demonstrate its use along the lines given below. Seeing is much better than merely reading.

This is not the place to consider the theory of the polarizing microscope except to note that in addition to the usual microscope optics it has two spaced elements, the polarizer and the analyzer, the first below and the second above the stage, the analyzer being readily movable in and out of the path of light. These elements respectively pass light vibrating in planes at right angles to each other. Equally important is the rotatable stage, for one does not merely look at an object through a polarizing microscope, he sees what happens when the object on the stage is oriented in particular ways relative to the polarizer and analyzer. The polarizing elements without a rotatable stage or some means of rotating them relative to a stationary stage would be valueless. As to its use it is sufficient to say that while isotropic substances (having their optical properties the same in all directions) remain dark when rotated on the stage between the polarizer and analyzer, anisotropic substances (whose optical properties depend on direction) will show brightness in some positions of rotation of the stage and darkness in others.

The most strongly anisotropic part of a moss leaf is its costa, owing to the fact that a costa is generally relatively thick and composed of a bundle of long cells close together with their cellulose chains longitudinal. The same is true of a border of the type occurring in *Mnium,* and less strongly so in *Bryum.* If the border has teeth the cellulose chain direction in them is longitudinal with respect to the teeth, not the border. If a slide including a costate leaf is mounted on the stage of a polarizing microscope and rotated into position to make the costa brillant (which occurs four times during a rotation of the stage through 360°), it is easy to see

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the exact length of the costa and whether or not it merges with the border. This is particularly useful with faint costas. This is perhaps a trivial case, but since my own microscope is a polarizing one, I examine every costa and border by polarized light as a matter of routine. It is just a matter of pushing a button to throw the analyzer into position and then rotating the stage. It should be noted, however, that a plication or crease on a leaf will give an appearance quite similar to a costa, and that a leaf with a revolute margin will look under polarized light much as if it had a border. Familiarity with these spurious costas and borders and checking with ordinary light are the only ways to avoid confusion.

A much more interesting use is in connection with the cell walls of moss leaves. Leaf cells are typically (but far from universally) flat with boundary walls at right angles to the plane of the leaf. These boundary walls show the cellulose chains in side view and are bright under polarized light in certain positions of the stage (analyzer, of course, inserted). With the gypsum plate employed as described below, the chains in these boundary walls prove to be longitudinal with respect to the wall, not surprising when it is remembered that the chains have to lie in the plane of the walls (Preston, 1952, p. 65). Those cell walls in the plane of the leaf, however, frequently do not show up in polarized light except by a faint reflection from the boundary walls. This does not mean that they have no cellulose chains but is a result of the fact that the chains in opposite walls are nearly at right angles and in the optical sense cancel each other (Preston, 1952, pp. 65-66). It would be only if the cells could be cut parallel to the plane of the leaf blade so as to show but a single wall that the direction of the chain in that wall could be demonstrated (Preston, 1952, p. 116), a very difficult operation on cells as thin as those of moss leaves. To determine the direction of the cellulose chains in both flat walls of the leaf cells jointly, which is generally sufficient, resort must be had to a method employing an accessory plate of gypsum between the polarizer and analyzer.

The method is described in Preston (1952) on pages 50-66 and briefly on page 151 of Taylor (1959). It consists in inserting the gypsum plate in the accessory slot of a polarizing microscope, introducing the analyzer, placing a mounted leaf on the rotatable stage, and rotating the stage until the test area of the leaf being studied is dark. Of course, if the leaf is isotropic, as it will be if the chains in opposite faces of the cells are at right angles and in approximately equal amounts (Preston, 1952, p. 109), or if they have a random orientation, this method does not apply since the leaf would be dark no matter how it was rotated. The position of the

stage when the test area is dark is called an extinction postion, there being another extinction position at right angles to it. If the stage is rotated slowly clockwise from one of the extinction positions the test area turns blue or green; if it is rotated clockwise from the other extinction position the area turns yellow. In the first extinction position the cellulose chains run N—S (toward and away from the observer) as indicated by the cross hairs in the eyepiece, and that position is the one always used.

As stated above, in some cases the opposite cell walls lying in the plane of the leaf blade have their respective cellulose chains at an angle to each other, so that their individual directions cannot be told unless it is possible to make a section parallel to that plane to separate the walls. In other cases the chains in the two flat cell walls are nearly parallel to each other rather than lying at a substantial angle. Their exact angle cannot be told without a parallel section, but the smallness of the angle between them can be surmised roughly by their brightness when rotated half way between extinction positions. Walls of this character are frequently found in the median cells of the Hypnaceae, for example. In *Hedwigia ciliata* they are found in a central patch running from the base up to about one-fifth the length of the leaf and consisting of cells elongated in that direction. By the described test with the gypsum plate it is found that the bisectrix of the angle between the chains in the parallel flat walls of the cells in this patch extends longitudinally of the leaf, if indeed the two sets of chains do not have the same direction. Certainly the cellulose chains themselves cannot depart much from the bisectrix, since the patch is very bright in polarized light.

Now it is clear that swelling is brought about by water entering between the cellulose chains and forcing them apart, so that swelling must occur at right angles to the chains, in this case transversely of the leaf. This gives a basis for explaining the hygroscopic movement of the *Hedwigia* leaf. It should be noted that, except for the patch of elongated cells, the leaf is formed of smaller, thick-walled and isotropic cells and that the basal edge and corners of the leaf are firmly secured to the stem. If the cells in the patch swell transversely, the tendency to bulge can be satisfied only by the leaf's swinging on its basal edge as a hinge, coupled with an increase in concavity, since the cells adjacent the basal edge cannot move sideways owing to the attachment to the stem. This is, of course, what occurs.

The transformation of the *Hedwigia* plant from the dry to the wet state is so striking that it would seem to require a vital process,

whereas the explanation above is purely mechanistic. To test this point two *Hedwigia* stems were taken. One was treated in FPA (Johansen, 1940, p. 42) for 48 hours, the other left untreated. Both plants were then dried and re-wetted; they acted exactly the same. Since the treatment with FPA terminated all life processes, it is clear that the action of the leaves on drying and re-wetting was mechanical and not vital.

The general condition is for the median cells to have longitudinal structure and the basal and alar cells transverse structure, although other combinations will be found. It will be noted, however, in leaves with a cordate or auricular base that the usual median structure is with the cellulose chains longitudinal of the cells, the long dimension of the cells following a tangent to the curve of the leaf base. The direction of the cellulose chains in leaves with thick-walled or papillose cells is generally impossible to ascertain by this technique, presumably because there is a lack of uniformity in the direction of the chains throughout the thickened cell walls.

Some pecularities of moss leaves brought out by the polarized light technique might prove in certain cases to have diagnostic value and, in any event, are interesting. As an example of the sort of thing that may be found, we may consider *Mnium cuspidatum, menziesii* and *punctatum*. These have a patch of cells at each side of the base of the costa in which the cellulose chains run transversely of the leaf, a condition not distinguishable without polarized light. This also appears in some other *Mnium* and *Bryum* species when fresh but has a tendency to disappear in old herbarium specimens, apparently because of masking of the polarization colors as the leaf darkens with age.

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A BRYOLOGICAL CONTRIBUTION FROM FLORIDA. II.

HOWARD CRUM AND LEWIS E. ANDERSON[1]

After a brief trip to Florida in January 1959 we published a sizable list of range extensions and county records (Bryol. 63:32-46. 1960). In March 1960 we spent a few days in northern Florida as a part of an extensive search in the Southeast for pygmy mosses. Again a number of interesting collections were made, and it seems worthwhile to list the more noteworthy ones here, particularly in view of the fact that Dr. Ruth S. Breen's valuable manual of Florida mosses is nearing completion, and it is hoped that our records will complement and aid in substantiating hers. Listed below are 47 species of mosses, of which two, *Thuidium pygmaeum* and *Amblystegiella confervoides*, are reported for the first time from the state; the remainder appear to be first records for counties. Complete series of the specimens are filed at Duke University and the National Museum of Canada. We are indebted to Dr. H. L. BLOMQUIST for determining the *Sphagna*.

Sphagnum cuspidatum var. *serrulatum* Schlieph. Near Fenholloway, Taylor Co., 13651.

Sphagnum erythrocalyx Hampe. Near Fenholloway, Taylor Co., 13652. Small stream near Fountain, Bay Co., 13718.

Sphagnum imbricatum Hornsch. Small stream near Fountain, Bay Co., 13716.

Sphagnum palustre L. Swamp, 7 mi. NE. of Bryceville, Nassau Co., 13553.

Sphagnum portoricense Hampe. Small stream near Fountain, Bay Co., 13719.

Sphagnum recurvum P.-Beauv. Floating in roadside ditch, 2.5 mi. N. of Lake City, Columbia Co., 13613. Submerged in roadside ditch, 3 mi. E. of Trenton, Gilchrist Co., 13631.

Fissidens cristatus Wils. *ex* Mitt. & Wils. On limestone, Florida Caverns State Park, Marianna, Jackson Co., 13682.

Fissidens ravenelii Sull. On red clay bank, 8 mi. N. of Cottondale, Jackson Co., 13724. On sandy clay, wall of animal burrow, Campbellton, Jackson Co., 13729.

Pleuridium subulatum (Hedw.) Rabh. 10 mi. W. of Gainesville, Alachua Co., 13625; 10 mi. E. of Marianna, Jackson Co., 13710 *p.p.* (with *Ephemerum crassinervium* var. *texanum*).

Ditrichum pusillum (Hedw.) Hampe. On clay bank, small stream near Fountain, Bay Co., 13717.

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[1] National Museum of Canada, Ottawa; Dept. of Botany, Duke University, Durham, N. C.—Grateful acknowledgment is made to the National Science Foundation for research grant G23-222 (to Duke University), which made this study possible.

Dicranella varia (Hedw.) Schimp. On calcareous clay, steep, shaded roadbank, near Florida Caverns State Park, Marianna, Jackson Co., 13709.

Dicranum condensatum Hedw. On sand, sandhill, about 5 mi. E. of Fountain, Bay Co., 13712.

Dicranum scoparium Hedw. On sand, Santa Fe River, O'Leno State Park, Columbia Co., 13644.—This may be the first certain record for Florida of this very widespread species. In a recent review of a large amount of material from North America, the only Florida specimen which we could verify was a collection made at Azalar, near Biltmore, by Mrs. M. B. Streeter, March 17, 1901 (DUKE-ABS). We doubted whether her specimen actually came from Florida because she had also collected in Wyoming in 1901 and had confused the data for at least one other specimen (*Campylopus flexuosus*, NY *sub C. tallulensis*, supposedly from Wyoming, a virtual phytogeographic impossibility).

Syrrhopodon texanus Sull. On rotten log, hardwoods, 16 mi. N. of Lake City, Columbia Co., 13614; on rotten log, Santa Fe River, O'Leno State Park, Columbia Co., 13641.

Weissia controversa Hedw. On clay bank, 2 mi. N. of Capps, Jefferson Co., 13654 *p.p.* (with *Philonotis sphaericarpa*).

Weissia jamaicensis (Mitt.) Grout. On limestone, old quarry, 4 mi. E. of Branford, Suwanee Co., 13649.

Tortella humilis (Hedw.) Jenn. On rotten log, Santa Fe River, O'Leno State Park, Columbia Co., 13642.

Barbula agraria Hedw. On limestone in old quarry, 4 mi. E. of Branford, Suwanee Co., 13650.

Ephemerum crassinervium (Schwaegr.) Hampe. On rather sandy soil in old field, 10 mi. W. of Gainesville, Alachua Co., 13623; on sandy soil, old field, 4 mi. SW. of Donaldsonville, Seminole Co., 13667.

Ephemerum crassinervium var. *texanum* (Grout) Bryan & Anderson. On soil in old field, among *Andropogon*, 10 mi. E. of Marianna, Jackson Co., 13710.

Ephemerum spinulosum Schimp. On red clay bank, 8 mi. N. of Cottondale, Jackson Co., 13725.

Bryum capillare Hedw. On sandy soil at edge of swamp, hardwoods, 16 mi. N. of Lake City, Columbia Co., 13617.

Philonotis glaucescens (Hornsch.) Par. On red clay bank, 8 mi. N. of Cottondale, Jackson Co., 13724 *p.p.* (with *Fissidens ravenelii*).

Schlotheimia rugifolia (Hook.) Schwaegr. On hardwood, swamp, Alford, Jackson Co., 13723.

Cryphaea nervosa (Hook. & Wils.) BSG. On dead stick on ground, hardwood stand, 16 mi. N. of Lake City, Columbia Co., 13630.

Forsstroemia trichomitria (Hedw.) Lindb. On bark of hardwood, 16 mi. N. of Lake City, Columbia Co., 13619.

Leucodon julaceus (Hedw.) Sull. On hardwood trunk, Santa Fe River, O'Leno State Park, Columbia Co., 13643; on bark of oak, 6 mi. E. of Malone, Jackson Co., 13668 *p.p.* (with *Clasmatodon parvulus*), 13669.

Pireella pohlii (Schwaegr.) Card. On bark of hardwood, Manatee Springs State Park, Levy Co., 13635; on limestone, Florida Caverns State Park, Marianna, Jackson Co., 13689.

Thelia hirtella (Hedw.) Sull. On rotten tree trunk, hardwood stand, 16 mi. N. of Lake City, Columbia Co., 13618; on bark at base of oak, Santa Fe River, O'Leno State Park, Columbia Co., 13648.

Clasmatodon parvulus (Hampe) Sull. On bark of hardwood, hardwood

stand, 16 mi. N. of Lake City, Columbia Co., 13620; on bark at base of hardwood and on a rotten log, hardwood flat, Fannin Springs, Gilchrist Co., 13627, 13628 *p.p.* (with *Haplocladium microphyllum*).

Leskea australis Sharp. On bark at base of oak, Santa Fe River, O'Leno State Park, Columbia Co., 13647.

Anomodon attenuatus (Hedw.) Hüb. Bark at base of hardwood, hardwood flat, Manatee Springs State Park, Levy Co., 13634.

Anomodon minor (Hedw.) Fürnr. On limestone, Florida Caverns State Park, Marianna, Jackson Co., 13702, 13703.

Haplohymenium triste (Ces.) Kindb. On bark of maple, Florida Caverns State Park, Marianna, Jackson Co., 13705.

Herpetineurum toccoae (Sull. & Lesq.) Card. On bark at base of hardwood, Manatee Springs State Park, Levy Co., 13640.

Haplocladium microphyllum (Hedw.) Broth. On rotten log, hardwood flat, Fannin Springs, Gilchrist Co., 13628.

Thuidium minutulum (Hedw.) BSG. On rotten log and on limestone, Florida Caverns State Park, Marianna, Jackson Co., 13674, 13683.

Thuidium pygmaeum BSG. On shaded limestone, Florida Caverns State Park, Marianna, Jackson Co., 13692.—This is the first record for Florida of this minute and easily overlooked calciphile, which is rather rarely collected but widespread in eastern North America as far north as Ontario.

Campylium chrysophyllum (Brid.) Bryhn. On limestone, Florida Caverns State Park, Marianna, Jackson Co., 13679.

Amblystegiella confervoides (Brid.) Loeske. On limestone, Florida Caverns State Park, Marianna, Jackson Co., 13688.—This is the first Florida record for this small and inconspicuous calciphile, which is widespread in eastern North America but rather infrequently collected.

Brachythecium oxycladon (Brid.) Jaeg. & Sauerb. On limestone, Florida Caverns State Park, Marianna, Jackson Co., 13678.

Cirriphyllum boscii (Schwaegr.) Grout. On sand, Santa Fe River, O'Leno State Park, Columbia Co., 13645.

Stereophyllum leucostegum (Brid.) Mitt. On bark of hardwood, 16 mi. N. of Lake City, Columbia Co., 13616.

Sematophyllum adnatum (Mx.) E. G. Britt. On bark of old pine log, hardwood flat, Fannin Springs, Gilchrist Co., 13629.

Platygyrium repens (Brid.) BSG. On bark of oak, 6 mi. E. of Malone, Jackson Co., 13671.

Taxiphyllum geophilum (Aust.) Fl. On limestone, Florida Caverns State Park, Marianna, Jackson Co., 13683 *p.p.* (with *Thuidium minutulum*), 13687 *p.p.* (with *Fissidens bryoides*), 13693, 13694, 13696, 13698 *p.p.* (with *Fissidens cristatus*).

Atrichum angustatum (Brid.) BSG. On sand, Santa Fe River, O'Leno State Park, Columbia Co., 13644 *p.p.* (with *Dicranum scoparium*).

THE DELAWARE LICHENS COLLECTED BY COMMONS

W. L. Dix[1]

Alexander Commons (1829-1919) was born in Chester County, Pennsylvania, but did most of his collecting in Delaware. According to Harshberger's *Botanists of Philadelphia* he was largely self-educated on account of ill health and became interested in botany from reading his brother's copy of Darlington's *Florula Cestrica*. He had a collection of "nearly 3,000 species listed, of mosses over 60 species, hepatics 40 species, lichens 160 species, and of fungi 1,300 species." His collection of plants was given to the Academy of Natural Sciences of Philadelphia.

Of the 600 specimens in his lichen collection many are duplicates, and a large number are not identifiable enough to report. He seems to have had a predilection for crustose species such as *Arthonia, Lecidea,* or *Graphis,* but his collection has no specimens of such common genera as *Alectoria, Evernia, Stereocaulon,* or the Umbilicariaceae. I believe the identification of these specimens written on the labels was largely the work of Commons, but he may have had the assistance of John W. Eckfeldt, who was then curator of the lichen collection at the Academy of Natural Sciences.

For the re-examination and determination of the lichens of this collection thanks must be given to Mason E. Hale and M. Wirth of the Smithsonian Institution, W. L. Culberson of Duke University, John W. Thomson of the University of Wisconsin, Grace Howard of the University of Washington, who examined all the Ochrolechias, Albert W. Herre of Santa Cruz, California, who did all the work on the Usneas, and the late A. W. Evans of Yale University, who examined the Cladonias in 1946.

All these lichens were collected, with few exceptions, between 1885 and 1896. Habitat data when given follow that on the original labels. Where no credit for determination is given, I have accepted that of Commons.

Anaptychia heterochroa Vain. Mt. Cuba: On *Juniperus virginiana.* (Det. Hale).

Anaptychia hypoleuca (Mühl.) Mass. Faulkland: On fence rails. (Det. Dix). Naamans Creek: On elm. (Det. Hale).

Anaptychia palmatula (Mx.) Mass. Faulkland: On dry rocks. (Det. Hale). Townsend: On bark of *Pinus.* (Det. Hale). Wilmington: On

[1] The Academy of Natural Sciences, Philadelphia, Pa.

dry rocks, bark of twigs, and white oak. (Det. Hale). On base of trees. (Det. Thomson).

Anatychia speciosa (Wulf.) Mass. FAULKLAND: In moss on bark. (Det. Hale). On cedar bark. (Det. Thomson). NAAMANS CREEK: On rocks with *Parmelia aurentula*. (Det. Hale). WILMINGTON: On rocks, base of trees. (Det. Hale).

Anthracothecium pyrenuloides (Mont.) Müll. Arg. LAUREL: On holly. (Det. Wirth).

Anzia colpodes (Ach.) Stzb. On bark of oak. (Det. Hale). LAUREL: On bark. (Det. Culberson).

Arthopyrenia cinchonae (Ach.) Müll. Arg. PENNSVILLE: On oak bark. (Det. Wirth).

Arthothelium spectabile (Flot.) Mass. NAAMANS CREEK: On *Tilia*. FAULKLAND, WILMINGTON: On *Juglans cinerea*. (Det. Wirth).

Arthothelium taediosum (Nyl.) Müll. Arg. FAULKLAND: On *Juglans cinerea*. MT. CUBA: On white walnut. (Det. Wirth).

Bacidia inundata (Fr.) Korb. FAULKLAND: On bricks. NEWARK: On rocks subject to inundation. (Det. Wirth).

Bacidia luteola (Schrad.) Mudd. CLAYMONT: Bark of *Ostrya virginica*. *Carya*, and *Juglans cinerea*. WILMINGTON: On bark of *Carpinus*. (Det. Wirth).

Bacidia schweinitzii (Tuck.) Schneid. FAULKLAND: On bark of ash. WILMINGTON: On *Quercus falcata* and *Carya*. (Det. Wirth).

Bacidia umbrina (Ach.) Bausch. WILMINGTON: On rocks. (Det. Wirth).

Baeomyces roseus Pers. MILFORD: Clayey banks. PENCADER HEAD: Sterile banks. WILMINGTON: Sterile ground.

Buellia conspirans (Nyl.) Vain. NEWARK: On red maple. SMYRNA: On bark of trees. WILMINGTON: On *Carpinus*. (Det. Wirth).

Buellia curtisii (Tuck.) Imsh. MT. CUBA: Bark of *Alnus*. (Det. Wirth).

Buellia punctata (Hoffm.) Mass. WILMINGTON: On *Acer rubrum* and *Kalmia latifolia* WOODLAND BEACH: On dead branches of *Baccharis*. Var. *polyspora* (Willey) Fink. WILMINGTON: On red maple. (Det. Wirth).

Buellia saxatilis (Schaer.) Körb. FAULKLAND: On *Acer rubrum*. (Det. Wirth).

Buellia stillingiana Stein. FAULKLAND: On bark. KENT CITY: On bark of holly. KIRKWOOD: On *Quercus palustris*. LAUREL: On bark of white cedar. MT. CUBA: On bark of *Alnus*. NEWARK, RUTHBY STATION: On *Acer rubrum*. SMYRNA: On bark of *Alnus serrulata*. WILMINGTON: On bark of *Acer rubrum* and chestnut. (Det. Wirth).

Buellia vernicoma Tuck. LAUREL: On *Magnolia glauca*. (Det. Wirth).

Calicium albonigrum Nyl. WILMINGTON: On *Cornus florida*, *Pinus rigida*, and *Liquidambar*.

Caloplaca camptidia (Tuck.) Zahlbr. On bark of *Carya*. (Det. Wirth).

Caloplaca cerina (Ehrh.) T. Fr. FAULKLAND: On bark of *Juglans cinerea*. NEWARK: On cedar bark. (Det. Wirth).

Caloplaca citrina (Hoffm.) T. Fr. FAULKLAND: On rocks. NAAMANS CREEK: On inundated rocks. (Det. Wirth).

Caloplaca diphasia (Tuck.) Rudolph. LAUREL: On white cedar bark. FAULKLAND: On trees. (Det. Wirth).

Caloplaca lobulata (Floerke) Hellbr. CENTERVILLE, MT. CUBA: On serpentine rocks. (Det. Wirth).

Caloplaca sideritis (Tuck.) Zahlbr. FAULKLAND: On rocks.

Candelaria fibrosa (Fr.) Müll. Arg. FAULKLAND: On *Juglans cinerea*. (Det. Hale).

Cetraria ciliaris Ach. LAUREL: On pine trunk. FAULKLAND: On fence rails. WILMINGTON: On bark of oaks. (Det. Hale).

Cetra .. fendleri (Nyl.) Tuck. TOWNSEND: On *Pinus rigida*. (Det. Hale).

Cetraria juniperina (L.) Ach. LAUREL: (Det. Hale).

Cetraria tuckermanii Oakes. FAULKLAND. On fence rails. (Det. Hale).

Cladonia apodocarpa Robbins. FAULKLAND, MILL CREEK, NEWARK, WILMINGTON: On sterile ground.

Cladonia atlantica fo. *ramosa* Evans. WILMINGTON: On sterile ground.

Cladonia capitata fo. *imbricatula* (Nyl.) Evans. COLLINS BEACH, FAULKLAND: On ground. MT. CUBA: On hillside. NAAMANS CREEK. Fo. *abbreviatula* (Vain.) Evans. COLLINS BEACH: On ground.

Cladonia caespiticia (Pers.) Floerke. FARNHURST: On base of trees. FAULKLAND, MT. CUBA, NAAMANS CREEK: On dry rocks. WILMINGTON: On trunk of living *Quercus*.

Cladonia cariosa (Ach.) Spreng. WILMINGTON: On sterile ground.

Cladonia chlorophaea (Floerke) Spreng. FAULKLAND: On ground.

Cladonia clavulifera Vain. WILMINGTON. Fo. *pleurocarpa* Robbins. WILMINGTON: On sterile ground.

Cladonia coniocraea (Floerke) Spreng. WILMINGTON: On sterile ground.

Cladonia cristatella fo. *beauvoisii* (Del.) Vain. DAGGETTS MILLS: On earth. FAULKLAND, LAUREL, WILMINGTON: On ground, stumps, and decaying white oak. Fo. *vestita* Tuck. COLLINS BEACH: On fence rails. FAULKLAND, PENCADER HEAD: In moss on ground. WILMINGTON: On fence rails.

Cladonia cryptochlorophaea Asahina. CENTERVILLE: On ground.

Cladonia didyma (Fée) Vain. MT. CUBA, WILMINGTON: On stumps.

Cladonia furcata var. *racemosa* (Hoffm.) Floerke. CENTERVILLE (1865). PENCADER HEAD, WILMINGTON: On sterile ground. FAULKLAND: On ground. MT. CUBA.

Cladonia grayi fo. *carpophora* Evans. MT. CUBA, WILMINGTON: On rocks. LAUREL: In pine woods. Fo. *squamulosa* Vain. PENCADER HEAD: In moss on earth.

Cladonia macilenta fo. *corticola* Vain. WILMINGTON.

Cladonia mateocyatha Robbins. WILMINGTON, NEWARK.

Cladonia nemoxyna fo. *fibula* Vain. FAULKLAND: On ground.

Cladonia papillaria fo. *molariformis* (Hoffm.) Schaer. STANTON, WILMINGTON: On sterile banks. Fo. *papillosa* Fr. FAULKLAND, STANTON: On sterile banks. WILMINGTON: On sterile clay banks.

Cladonia pleurota (Floerke) Schaer. FAULKLAND: On sterile ground. MT. CUBA: On rotten wood. WILMINGTON: On earth in woods.

Cladonia pyxidata fo. *pocillum* (Ach.) Fw. FAULKLAND: On old cedar shingles. NEWCASTLE.

Cladonia robbinsii Evans. WILMINGTON: On sterile ground.

Cladonia squamosa (Scop.) Hoffm. MT. CUBA: On sterile ground.

Cladonia strepsilis fo. *coralloides* Vain. FAULKLAND: On bark. NEWARK.

Cladonia subcariosa Nyl. NEWARK: On sterile banks. Var. *evoluta* Vain. FAULKLAND: On rocks. WILMINGTON: On sterile ground. Fo. *squamulosa* Robbins. WILMINGTON: On sterile banks.

Cladonia subtenuis (des Abb.) Evans. CENTERVILLE (1865), DAGGETTS MILLS, MT. CUBA, NEWARK, PENCADER HEAD, WILMINGTON: On sterile ground.

Cladonia verticillata (Hoffm.) Schaer. FAULKLAND. Fo. *apoticta* (Ach.) Vain. WILMINGTON. Fo. *aggregata* (Del.) Oliv. WILMINGTON. All on ground.

Collema conglomeratum Hoffm. NAAMANS CREEK: On rotten logs. (Det. Wirth).

Coniocybe gracilescens Willey. MT. CUBA: (Det. Wirth).

Conotrema urceolatum (Ach.) Tuck. FAULKLAND: On bark. KIRKWOOD: On *Acer rubrum.*

Cyphelium tigillare Ach. CLAYMONT: On old cedar rails. (Det. Wirth).

Dermatina pyrenocarpa (Nyl.) Zahlbr. CHRISTIANA HEAD: On trees. FAULKLAND: On *Juglans cinerea.* NEWARK: On maple, *Magnolia,* and *Carpinus.* (Det. Wirth).

Dermatocarpon fluviatile (Web.) T. Fr. FAULKLAND: On wet rocks. NEWARK: On rocks subject to inundation. (Det. Wirth).

Dermatocarpon hepaticum (Ach.) T. Fr. CHRISTIANA HEAD: On serpentine rocks. MT. CUBA: On serpentine barrens. (Det. Wirth).

Dermatocarpon miniatum (L.) Mann. FAULKLAND: On wet rocks. GREENBANK: On wet banks. WILMINGTON: On dry shaded rocks. (Det. Wirth).

Dermatocarpon tuckermanii (Rav.) Zahlbr. WILMINGTON. (Det. Wirth).

Graphis lineola Ach. WILMINGTON: On living *Magnolia glauca.* (Det. Wirth).

Graphis tenella Ach. HARVEYS STATION: On red maple. WILMINGTON: On *Magnolia glauca.* (Det. Wirth).

Gyrostomum scyphuliferum (Ach.) Fr. ELLENDALE: On red maple. (Det. Wirth).

Lecanora atra (Huds.) Ach. No location; Commons' label: "#135 J. W. E.," Eckfeldt's initials. (Det. Wirth).

Lecanora pallida (Schreb.) Rabh. FAULKLAND: On red maple and *Juglans cinerea.* FELTON, HARVEYS STATION, NEWARK, RUTHBY STATION, WILMINGTON: On red maple. LAUREL: On holly. MT. CUBA: On *Alnus* and white walnut. SMYRNA: On bark of trees. (Det. Hale).

Lecanora varia (Ehrh.) Ach. FAULKLAND: On fence rail. LAUREL. On white cedar. WILMINGTON: On bark of *Acer rubrum,* chestnut, *Prunus cerasus, Nyssa,* and *Ailanthus.* WOODLAND BEACH: On sweet gum. (Det. Hale).

Lecidea albocaerulescens (Wulf.) Ach. NAAMANS CREEK, MT. CUBA, FAULKLAND, WILMINGTON: On rocks.

Lecidea cadubriae (Mass.) Nyl. WILMINGTON: On roots *of Betula lenta.*

Lecidea contigua (Hoffm.) Fr. NAAMANS CREEK, WILMINGTON: On stones in woods.

Lecidea cyrtidia Tuck. FAULKLAND: On rocks. (Det. Wirth).

Lecidea varians Ach. FAULKLAND: On *Acer rubrum* and *Juglans cinerea.* MT. CUBA: On bark of *Celtis.* NEWARK: On bark of *Acer rubrum* (Det. Wirth).

Leptogium chloromelum (Sw.) Nyl. "UP ALLOPAKE": On bark of trees. (Det. Hale).

Leptogium pulchellum (Ach.) Nyl. FAULKLAND: On base of trees. WILMINGTON: On white walnut bark.

Leptogium tremelloides (L.) S. Gray. WILMINGTON: On rocks and base of trees.

Lobaria amplissima (Scop.) Forss. "ALLOPAKE": On *Platanus*. FALLS OF SHELLPOT: On *Platanus*. CARRCROFT STATION, LAUREL: Base of trees. MT. CUBA, NAAMANS CREEK: On dry rocks. WILMINGTON: On trunks of *Platanus*.

Lobaria laetevirens (Lightf.) Zahlbr. LAUREL: At base of trees.

Lobaria pulmonaria (L.) Hoffm. MT. CUBA: On rocks. CENTERVILLE: On trunk of oak.

Lobaria quercizans MT. CUBA: On rocks. SHELLPOT FALLS: In moss. WILMINGTON: On rocks.

Microphiale lutea (Dicks.) Zahlbr. RUTHBY: On rotten oak wood.

Microthelia thelena (Ach.) Trev. MT. CUBA: On bark of *Fraxinus sambucifolia*.

Ocellularia subtilis (Tuck.) Ridd. FAULKLAND: On *Juglans cinerea*. LAUREL: On *Magnolia glauca*.

Ochrolechia geminipara (T. Fr.) Vain. NAAMANS CREEK: Moss over rocks.

Ochrolechia pallescens (L.) Mass. LAUREL, WILMINGTON; On maple trunks.

Ochrolechia tartarea (L.) Mass. FAULKLAND, NAAMANS CREEK: On bark and rocks. WILMINGTON: On trunks of living *Acer rubrum*.

Opegrapha atra Pers. FAULKLAND: On bark of *Carya*.

Pannaria leucosticta Tuck. ELLENDALE: On red maple.

Pannaria lurida (Mont.) Nyl. LAUREL, TOWNSEND. On oak and hickory bark.

Parmelia aurulenta Tuck. MT. CUBA, WILMINGTON: On dry rocks. NAAMANS CREEK: On rocks. (Det. Culberson).

Parmelia caperata (L.) Ach. COLLINS BEACH, FAULKLAND: Fence rails. (Det. Culberson). MT. CUBA, TOWNSEND, WILMINGTON: On dry rocks. PENNSVILLE: On *Juniperus*. STANTON: On dead wood.

Parmelia cetrata Ach. COLLINS BEACH.

Parmelia conspersa Ach. FAULKLAND: On dry rocks.

Parmelia formosana Zahlbr. LAUREL: On trucks of pines. (Det. Hale).

Parmelia furfuracea (L.) Ach. FAULKLAND: On old rails.

Parmelia galbina Ach. KIRKWOOD: On pin oak. NEWARK: On red maple. RUTHBY STATION: On tree trunks. TOWNSEND: On trees. WILMINGTON: On dead wood. (Det. Culberson).

Parmelia hypotropa Nyl. COLLINS BEACH: On fence rails. (Det. Culberson). LAUREL: With *P. hypotropoides*, on pine stumps. (Det. Hale). NEWARK: On *Acer rubrum*, with *P. hypotropoides*. (Det. Culberson). PENNSVILLE: On trunks of trees. (Det. Hale). WILMINGTON: On *Ailanthus*. (Det. Culberson).

Parmelia hypotropoides Nyl. LAUREL: On trees. (Det. Hale). MT. CUBA: (Det. Culberson). NEWARK: On trunks of trees. (Det. Hale). SMYRNA (Det. Culberson). WILMINGTON: On laurel twigs. (Det. Culberson).

Parmelia livida Tayl. COLLINS BEACH, FAULKLAND: On fence rails. ELLENDALE: On *Acer rubrum*. KIRKWOOD, MT. CUBA: On bark. LAUREL: On pine and laurel. RUTHBY STATION: On tree trunks. TOWNSEND: On river bank. WILMINGTON: On *Ailanthus*. (Det. Culberson).

Parmelia perforata (Jacq.) Ach. LAUREL: On pine trunks. (Det. Hale). KIRKWOOD: With *P. cetrata*. MT. CUBA: On bark. (Det. Hale).

SMYRNA: On bark of trees. WOODLAND: On laurel twigs. WOODLAND BEACH. (Det. Hale).

Parmelia perlata (Huds.) Ach. FAULKLAND: On trunk of apple trees. LAUREL: On tree trunk. (Det. Culberson).

Parmelia physodes (L.) Ach. FAULKLAND: On fence rails. (Det. Culberson). TOWNSEND: On trees.

Parmelia reticulata Tayl. LAUREL: On tree trunks. (Det. Culberson).

Parmelia rudecta Ach. CARRCROFT: On trunks. (Det. Culberson). FAULKLAND: On fence rails. (Det. Culberson). LAUREL: On trees. (Det. Culberson). NEWARK: On bark of trees. (Det. Hale). WILMINGTON: On *Ailanthus.* (Det. Hale).

Parmelia saxatilis (L.) Ach. FAULKLAND: On dry rocks.

Parmelia stenophylla (Ach.) Heug. FAULKLAND: On rocks. (Det. Culberson).

Parmelia sulcata Tayl. FAULKLAND: On trunks of *Celtis.* (Det. Hale).

Parmelia trichotera Hue. FAULKLAND: On trunks of maple. MT. CUBA. (Det. Hale).

Parmeliopsis ambigua (Wulf.) Nyl. LAUREL: On trunk of pines.

Peltigera aphthosa (L.) Willd. MT. CUBA, NEWPORT: Base of trees. FAULKLAND: On wet rocks. HIGH BRIDGE: E. side of Brandywine.

Peltigera canina (L.) Willd. FALLS OF SHELLPOT, FAULKLAND, WILMINGTON: Base of trees. Var. *rufescens* (Weis.) Mudd. FAULKLAND: On wet rocks. LAUREL: In sandy pine woods. WILMINGTON: On earth. (Det. Thomson).

Peltigera polydactyla (Neck.) Hoffm. NAAMANS CREEK: Base of stump. WILMINGTON: Mossy bank along stream. (Det. Thomson).

Peltigera rufescens (Weis.) Humb. FAULKLAND: On ground. MILL CREEK HEAD: In moss. MT. CUBA, WILMINGTON: On rocks. NAAMANS CREEK: On earth. NEWARK: On sterile bank.

Pertusaria glomerata (Ach.) Schaer. WILMINGTON: On mosses.

Pertusaria leioplaca (Ach.) DC. WILMINGTON: On red maple twig.

Pertusaria marginata Nyl. WILMINGTON: On bark of *Carpinus.*

Pertusaria multipuncta (Turn.) Nyl. FAULKLAND: On *Juglans cinerea.* LAUREL: On *Magnolia glauca.* WILMINGTON: On bark of *Liriodendron* and *Acer rubrum.*

Pertusaria pertusa (L.) Tuck. FAULKLAND: On *Fagus.* NEWARK: On *Acer rubrum.* SMYRNA: On bark. WILMINGTON: On bark of *Carpinus.*

Pertusaria pustulata (Ach.) Duby. WILMINGTON: On bark of chestnut, *Ailanthus,* and hickory.

Pertusaria velata (Turn.) Nyl. ELLENDALE: On bark of holly. FAULKLAND: On *Carya.* LAUREL: On *Magnolia.* MT. CUBA: On *Alnus.* NAAMANS CREEK: On *Liriodendron* and rocks. NEWARK: On *Magnolia glauca.* WILMINGTON, WOODLAND PARK: On *Liquidambar.*

Phaeographis dendritica (Ach.) Müll. Arg. HARVEYS STATION, WILMINGTON: On red maple. MT. CUBA: On *Alnus serrulata.*

Physcia aipolia (Ehrh.) Hampe. NAAMANS CREEK: On trunk of elm trees. (Det. Thomson).

Physcia ciliata (Hoffm.) DR. FAULKLAND: With *Physcia orbiculata,* on *Juglans cinerea.* NAAMANS CREEK: On bark of *Tilia.* (Det. Thomson).

Physcia grisea (Lam.) Zahlbr. NAAMANS CREEK: On elm tree trunk. (Det. Thomson).

Physcia millegrana Degel. FAULKLAND: With *Physcia orbicularis* on bark. MT. CUBA: On serpentine rocks and on *Celtis.* WILMINGTON: On

willow bark, on oak, and cedars. WOODLAWN BEACH, SMYRNA: On bark. (Det. Thomson).

Physcia orbicularis (Neck.) Thoms. FAULKLAND: On bark. MT. CUBA: On cedar bark. WILMINGTON: On *Juglans cinerea.* Fo. *rubropulchra* Degel. NAAMANS CREEK: With *Pyxine sorediata* on red maple. (Det. Thomson).

Physcia phaea (Tuck.) Thoms. NAAMANS CREEK: On rocks. (Det. Thomson).

Physcia stellaris (L.) Nyl. FAULKLAND: On bark. LAUREL: On poplar. MT. CUBA: With *Physcia millegrana* on bark of *Celtis.* Fo. *tuberculata* Kernst. SMYRNA: On bark. WILMINGTON: On dead branches. (Det. Thomson).

Physcia syncolla Tuck. FAULKLAND: On *Carya.* MT. CUBA: On *Celtis occidentalis.* (Det. Thomson).

Physcia tribacoides Nyl. FAULKLAND: On *Juglans cinerea.* OGLETOWN: On bark. (Det. Thomson).

Porina cestrensis (Tuck.) Müll. Arg. FAULKLAND: On bark of *Carya.* NAAMANS CREEK: On bark of hickory saplings. OGDEN STATION, WILMINGTON: On bark of *Carpinus.* (Det. Thomson).

Pyrenula aspistea (Apz.) Ach. NEWARK: On bark of *Hamamelis.* (Det. Wirth).

Pyrenula laevigata (Pers.) Arn. LAUREL: On *Hamamelis.* (Det. Wirth).

Pyrenula leucophaea (Wallr.) Körb. WILMINGTON: On *Acer rubrum.* (Det. Wirth).

Pyrenula nitida (Weig.) Ach. CLAYMONT: On *Tilia.* FAULKLAND: On beech and *Alnus.* NAAMANS CREEK: On bark of *Tilia* and *Hamamelis.* NEWARK: On *Quercus coccinea.* MT. CUBA, WILMINGTON: On bark of *Carpinus.* (Det. Wirth).

Pyxine sorediata (Ach.) Mont. FAULKLAND: On *Juglans cinerea.* LAUREL: On *Magnolia glauca.* WILMINGTON: On bark of *Carpinus.* (Det. Wirth).

Ramalina calicaris (L.) Röhl. REHOBETH.

Ramalina farinacea (L.) Ach. PENNSVILLE.

Ramalina fraxinea (L.) Ach. FAULKLAND, MT. CUBA, PENNSVILLE, and WOODLAWN BEACH.

Ramalina willeyi Howe. NAAMANS CREEK.

Rhizocarpon petraeum (Wulf.) Mass. LAUREL, NEWARK, AND WILMINGTON: On rocks.

Rinodina ascociscana Tuck. SMYRNA. (Det. Wirth).

Rinodina exigua (Ach.) S. Gray. WILMINGTON: On *Rhus toxicodendron.* (Det. Wirth).

Sarcogyne simplex (Dav.) Nyl. WILMINGTON: On rocks.

Sticta aurata Ach. CENTERVILLE: On bark of oak. ELLENDALE: On red maple. MT. CUBA: Among moss on rocks.

Teloschistes chrysophthalmus (L.) Beltr. FAULKLAND: On trees. KIRKWOOD: On red cedar. MT. CUBA: On bark of *Celtis* and rocks. NEWARK: On trees.

Trypethelium virens Tuck. FAULKLAND: On bark of *Fagus.* LAUREL: On *Magnolia glauca.* OGDEN STATION: On *Acer rubrum.* WILMINGTON: On *Betula lenta.* (Det. Hale).

Usnea seratina var. *incurvescens* (Arn.) Mot. MT. CUBA: On *Kalmia.*

Usnea pensylvanica Mot. LAUREL: On pine trunks.

Usnea strigosa (Ach.) Eaton. COLLINS BEACH, LAUREL, TOWNSEND: On trees. FAULKLAND: On pine trunks. NEWCASTLE: On old rails. SMYRNA.

Usnea trichodea (Ach.) MT. CUBA: On branches of *Kalmia latifolia*.

Usnea rubicunda Stirt. NEWCASTLE: On fence rails.

SOME MOSSES FROM MT. WASHINGTON, NEW HAMPSHIRE

RICHARD T. T. FORMAN[1]

In the course of some studies in the Mt. Washington area a few general collections were made, among which were the mosses reported below. Previous mosses reported from the mountain are published in Ammons (1934) and Grout (1899; 1940; 1928-40), which are largely collections in the alpine zone. With few exceptions, only noteworthy species which have not been previously reported from the mountain are included, although several were already represented in various herbaria. Duplicates of all specimens are deposited in the herbaria of the National Museum of Canada and the New York Botanical Garden.

Mt. Washington is in the White Mountains of northern New Hampshire, 71°41′N., 44°15′W., and is the highest mountain in northeastern United States at 6288 feet. Its principal vegetation is represented by typical northern hardwoods up to about 2500-2900 ft. elevation, spruce-fir up to about 4800-5200 ft., and alpine vegetation above. Tuckerman Ravine, the site of several collections, is an east-facing cirque with a precipitous rocky headwall extending upward from about 4000 ft.

The alpine zone of this mountain is noted for the large number of predominantly arctic species which comprise the flora. It is usually considered a glacial refugium for many plant and animal species found here at their southernmost limit. Most of the present mosses indeed have their centers of distribution many hundreds of miles northward and are disjunct representatives of the arctic and northern boreal forests.

[1] Division of Biology, University of Pennsylvania, Philadelphia, Pa.—It is a pleasure to acknowledge the aid of Dr. A. J. SHARP, who examined three specimens, as noted under each. The author is also grateful to the National Science Foundation for fellowships during which time the work was done and to the curators of the herbaria at Harvard University, the New England Botanical Club, and the New York Botanical Garden for the opportunity to examine certain specimens.

Finally, a search of the trap rock area of the Tuckerman Ravine headwall failed to locate *Brachydontium trichodes* in its only North American locality.

Tetrodontium brownianum Schwaegr. On siliceous rock in dark crevice below Glen Ellis Falls near Pinkham Notch, elev. 1800′, 7 Aug. 1960, B107 (det. A. J. Sharp). This rare species has now been collected seven times in New Hampshire. The present collection was composed almost entirely of numerous prothalloid structures (frondiform leaves) with only a few embryonic leafy shoots.

Tetraphis geniculata Girg. On rotten coniferous wood along brook approx. 800 yards WNW of Crystal Cascades in coniferous-deciduous ecotone, elev. 2700′, 6 Aug. 1960, B106. (*T. pellucida* also grew on this substrate.) This is the fourth locality in the state and the first in the Mt. Washington area. Of over 200 collections of *Tetraphis* from tree-line to the base of the mountain only one contained this species.

Tetraphis pellucida Hedw. On humus over rock next to seepage in small spruce-fir stand just above Alpine Gardens, elev. 5000′, 13 Aug. 1960, B413. The present locality was the highest on the mountain, where it extends from the deciduous woods right to tree-line.

Trematodon ambiguus (Hedw.) Hornsch. On wet clay in headwall of Tuckerman Ravine along trail, elev. about 4400′, 9 Aug. 1960, B309.

Distichium capillaceum (Hedw.) Br. & Schimp. On moist soil by Crystal Cascades above Pinkham Notch, elev. 2200′, 16 Aug. 1960, B116.

Blindia acuta (Hedw.) Br. & Schimp. In crack of siliceous rock in trap rock area of Tuckerman Ravine headwall, elev. about 4400′, 13 Aug. 1960, B413.

Dicranella rufescens (Sm.) Schimp. On soil along trail in headwall of Tuckerman Ravine, elev. about 4400′, 9 Aug. 1960, B109.

Rhabdoweisia denticulata (Brid.) Br. & Schimp. On wet rock below Glen Ellis Falls near Pinkham Notch, elev. 1800′, 7 Aug. 1960, B207.

Oncophorus wahlenbergii Brid. On humus in alpine heath of Alpine Gardens, elev. 5200′, 13 Aug. 1960, B113.

Tetraplodon mnioides (Hedw.) Schimp. On old bones at summit, 6200′, 13 Aug. 1960, B213. Reported as abundant in the nineteenth century around stables on top of the mountain, this species is now not uncommon on old bones strewn about the summit.

Amphidium mougeotii (Br. & Schimp.) Schimp. In cracks of rock face at Crystal Cascades above Pinkham Notch, elev. 2200′, B516 (det. A. J. Sharp).

Aulacomnium androgynum Schwaegr. On soil by boulder above Tuckerman Ravine headwall, elev. about 5000′, 9 Aug. 1960, B409 (det. A.J. Sharp).

Bartramia pomiformis Hedw. On rock face at Crystal Cascades above Pinkham Notch, elev. 2200′, 16 Aug. 1960, B216. Not common.

Philonotis caespitosa var. *compacta* Dism. In crack of rock along trail in headwall of Tuckerman Ravine, elev. about 4500′, 9 Aug. 1960, B209. Apparently this species has been collected only three times previously in the state.

Pohlia rothii (Correns) Broth. On soil along trail in headwall of Tuckerman Ravine, elev. about 4400′, 9 Aug. 1960, B609. This species was found mixed with two other propaguliferous species, *Pohlia bulbifera* and *P. annotina*. It might be noted that Hermann (1959) located the same three species growing together in the Adirondack Mountains of New York.

Pohlia annotina (Hedw.) Loeske. On soil along trail in headwall of Tuckerman Ravine, elev. about 4400′, 9 Aug. 1960, B709. (See under *P. rothii*.)

Pohlia bulbifera (Warnst.) Warnst. On soil along trail in headwall of Tuckerman Ravine, elev. about 4400′, 9 Aug. 1960. Grout's specimen (1935) from the White Mountains appears to be the only other collection in all of northern New England. (See under *P. rothii*.)

Mnium hornum Hedw. On wet soil by Winniweta Falls on Miles Brook, 6 mi. south of Mt. Washington and west of route 16, elev. 1300′, 14 Aug. 1960, B114.

Sematophyllum marylandicum (C. M.) E. G. Britt. On wet rock by stream along Old Jackson Road near Pinkham Notch, elev. 2300′, 8 Aug. 1960, B108.

Pterigynandrum filiforme Hedw. At base of tree in deciduous woods along Tuckerman Trail above Pinkham Notch, elev. about 2100′, 1 June 1960, B101 (*R. T. T. Forman & H. E. Robinson*).

Anacamptodon splachnoides (Froel.) Brid. In knothole of old *Acer saccharum* a few hundred yards up Sherburne Trail from route 16 near Pinkham Notch, elev. 2000′, 7 Aug. 1960, B307. At base of a crack on trunk of *Acer saccharum* near Tuckerman Trail just above Crystal Cascades near Pinkham Notch, elev. 2200′, 11 Aug. 1960, B111. In crotch of old *Betula lutea* 2-300 yards north of Pinkham Notch Camp, elev. 2000′, 16 Aug. 1960, B316. The three collections were made in the deciduous woods within 500 yards to the west of Pinkham Notch. Despite mature capsules with spores on the three collections, a search of all trees within 100 yds. of each failed to locate additional specimens.

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NOTES ON THE HEPATICAE OF ARIZONA

James A. McCleary[1]

Literature reports on the Hepaticae of Arizona are scarce. The most recent paper dealing exclusively with hepatics was written in 1939 by Little, who enumerated the species he had collected in the Sierra Ancha Mts. of central Arizona. Before that

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time few collections had been recorded (see Evans, 1917; Little, 1939).

During the time when the author was working on the mosses of Arizona, it was inevitable that he should also collect some liverworts. Surprisingly, both the actual number of specimens and species were limited. Nowhere are liverworts plentiful, and where they are found, the species are few.

Distribution of hepatics seems to be correlated with available moisture both as to time of year and location. The greatest number of species was collected at the Phelps Botanic Area in the White Mts. of Apache Co. at an altitude of about 9000 ft., where *Riccia frostii, Radula complanata, Pellia epiphylla, Marchantia polymorpha,* and *Frullania inflata* occupied their normal habitats. This protected region is a small mountain meadow through which a shallow, permanent stream meanders. Precipitation is probably more than 35 in. annually, with much of it coming in the form of snow. The incidence of summer days with thunder storms assures a higher average of humidity than in any other part of Arizona, although all these species, except for *Pellia epiphylla,* can be found elsewhere.

The opposite extreme of climatic conditions occurs in the Sonoran Desert region of central and southern Arizona (McCleary, 1959). Here *Riccia dictyospora* can be found after the early spring rains in moist, silty washes or in the shelter of common desert shrubs, such as the creosote bush (*Larrea tridentata*). *Targionia hypophylla* can also be found nearby, often sheltered by *Selaginella arizonica.* Interesting discoveries have also been made along mud flats which are exposed when irrigation demands have caused the water level in the storage dams to be lowered, as occurs every spring along Salt River. Here *Sphaerocarpus texanus* and *Riccia frostii* have been collected, the former by the author (1959a) and the latter by Little (1939).

Hemispheric distributions conform rather closely with those of vascular plants in that those hepatics which live in more xeric habitats show affinities to the west and south. Three groups can be distinguished on this basis: one, those which are found in western North America, including *Fossombronia longiseta, Asterella californica, Targionia hypophylla,* and *Riccia glauca;* two, those with ranges across most of the southern United States and southward, including *Marchantia domingensis, M. paleacea, Plagiochasma rupestre, P. wrightii, Sphaerocarpus texanus, Mannia californica,* and *Riccia trichocarpa;* three, those which are widespread throughout the entire hemisphere. This last group would include all other

species reported here, with the possible exception of *Riccia dictyospora* and *R. nigrella* whose ranges are not too well known.

Including the several records reported here for the first time, the total count of hepatics in Arizona includes 14 families, 18 genera, and 33 species. This total is not too far out of line with other southwestern states where the numbers are also small. The following collections are reported in the hope of stimulating interest among bryologists who may work in the state. No attempt is made to repeat records of previous reports.

Plagiochila asplenioides (L.) Dum. In water, Horton Creek, Mogollon Rim, Gila Co., ca. 6000 ft.; on rock, Mt. Lemmon, Pima Co., 7200 ft.

Porella platyphylla (L.) Lindb. North Rim of the Grand Canyon, Kanabownits Springs, 8300 ft. (*Rose Collom*); on rock, Oak Creek Canyon, 6050 ft.

Radula complanta (L.) Dum. Perhaps the most common liverwort in the state at higher altitudes in the Chiricahua, Sierra Ancha, San Francisco, Pinaleno, and Santa Catalina Mts.

Frullania inflata Gottsche. Rather common on rocks and trees in the Chiricahua Mts. of Cochise Co. above 8500 ft.; at 4800 ft. on Mt. Lemmon, Pima Co.; Workman Creek, Sierra Ancha Mts., Gila Co.

Pellia epiphylla (L.) Corda. A new record for Arizona, this has been found only within the confines of the Phelps Botanic Area.

Marchantia polymorpha L. Several collections have been made in water or moist regions at altitudes varying from 3600 ft. at Clear Creek, Grand Canyon National Park, to above 9000 ft. on Mt. Graham, Pinaleno Mts., Graham Co., Paradise Park and Phelps Botanic Area, White Mts., Apache Co., and at 7000 ft. at the Herb Martyr Reservoir, Chiricahua Mts., Cochise Co.

Plagiochasma rupestre (Forst.) St. Cave Creek, the Chiricahua Mts., Cochise Co., 6000 ft. (*Wm. Weber*).

Targionia hypophylla L. Common on bare soil from desert altitudes of below 1000 ft. to the pinyon-juniper areas at ca. 4500 ft., often occurring with *Selaginella*. Collections in the author's herbarium come from the east side of the Sierra Estrella Mts., Maricopa Co.; Gardner Canyon, Santa Rita Mts., Pima Co. (*Roy Johnson*); Boyce Thompson Arboretum near Superior, Gila Co.; and the Pinal Mts., south of Globe, Gila Co.

Riccia crystallina L. On wet mud flats along Salt River below Stewart Mt. dam.

Riccia dictyospora Howe. Common in early spring on soil in the Sonoran Desert; east side of the Sierra Estrella Mts., Maricopa Co., and many desert areas south and east to Guadalupe Canyon, Cochise Co., near Douglas.

Riccia fluitans L. In water of a seep-spring below the Second Falls, Havasu Canyon, Coconino Co. (*Elwood Blakley*).

Riccia frostii Aust. On bare soil, Phelps Botanic Area, White Mts., Apache Co.

Sphaerocarpus texanus Aust. On mud flats of Salt River below Stewart Mt. dam (*Roy Johnson*).

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POHLIA BULBIFERA—A NEW RECORD FOR MICHIGAN

DANA G. GRIFFIN III[1]

Pohlia bulbifera (Warnst.) Warnst. is characterized by numerous, yellow, rather solid, obovate, axillary gemmae. While on a field trip to Whitefish Point in Luce County in the Upper Peninsula of Michigan in 1960, the author collected this moss on white sand flats along the shore of Lake Superior. Here it occurred with the spermatophytes, *Hudsonia tomentosa* and *Potentilla tridentata,* frequently forming a green mat around the bases of the former. Reports of this species from North America are scanty; in Grout's *Moss Flora* Andrews listed collections only from Nova Scotia, New Hampshire, and Massachusetts.

Since the Michigan station is an area subjected to the rigors of ice heaving from Lake Superior during the winter and considerable superficial drying during the summer, the persistence there of such a delicate species is indeed remarkable, but perhaps it can be explained in part by the abundant gemmae. No fruiting material was found.

Specimens have been deposited in the herbaria of the University of Michigan Biological Station and of the University of Tennessee.

Dr. A. J. Sharp made the initial determination which was subsequently confirmed by Dr. A. L. Andrews. The author wishes to express appreciation to both persons for their help.

[1] Contribution from the University of Michigan Biological Station

REVIEWS

MASON E. HALE, JR.: *Lichen Handbook, a Guide to the Lichens of Eastern North America.* x + 178 pp. 58 fig., 20 pl, 3 tab. Smithsonian Institution, Washington, D. C. Publication 4434. 1961. (Cloth: $4.00.)—Botanists who teach a survey of the plant kingdom or general cryptogamic botany (or even introductory botany, for that matter) can no longer excuse their glossing over the lichens on the grounds that there is no good source of up-to-date information on lichenology. In a remarkably few pages, Dr. Hale now gives an outline of the biology of the lichens that goes far beyond what one might guess from the modest title of his book. The first 100 pages (and they are very little pages) concern the morphology, anatomy, reproduction, physiology, symbiosis, chemistry (in considerable detail), and economic aspects of lichens. The text is illustrated with good line drawings and the photographs (except those of the crystals of lichen substances) are excellent. The writing is lucid, straightforward, and unencumbered by literary references or hedging over trivial points and technical exceptions that would interest only the professional. The text often becomes almost a skeletal outline or teacher's syllabus, and in fact this book is largely based on lecture notes which Dr. Hale published some years ago in connection with a course in lichenology that he taught at that time.

The informal style of this book will doubtless arouse the criticism of some lichenologists. It would be well though for such potential critics to remember that this book is not addressed primarily to them. But from their knowledge of the literature of lichenology, they will be able to perceive something that will necessarily escape the amateur: in many places the information and interpretations given are really new and are not digests of the existing literature. In the end, it will also be a very knowledgeable lichenologist indeed who cannot read this book with profit.

The last 50 or so pages are given over to dichotomous keys to the most conspicuous lichens of the flora of eastern North America—the foliose and fruticose species. Although there are no separate descriptions for the species, the information in the keys alone and the many excellent photographs by Haskell Phillips should be enough for the identification of most species. There are also keys to the genera of crustose lichens. And at the end there is a good classified list of selected references.

This is a book to read now if you want to know something about lichenology in 1961. In five years it will be out of print and (I hope for the sake of lichenology) obsolete. In the meantime, let us thank Dr. Hale for a readily understandable statement of contemporary lichenology.—W. L. CULBERSON.

ELSA NYHOLM: *Illustrated Moss Flora of Fennoscandia.* II. Musci. Fasc. 4, pp. 287-408, fig. 163-259. (1960). 1961. C. W. K. Gleerup, Lund. (15:50 Swedish crowns.)—This, the fourth fascicle of Dr. Nyholm's compact and attractive manual, includes 17 families (Timmiaceae through Fabroniaceae). Most of the 39 genera present few taxonomic problems, but the treatment of *Philonotis, Fontinalis,* and *Lescuraea,* nasty genera wherever they occur, will be nearly as useful on this continent as in Europe. It is noted with satisfaction that *Thiudium minutulum* is segregated as *Microthiudium,* but *Stroemia* seems a much less well marked segregate from *Orthotrichum.* A useful new combination, *Pseudoleskeella nervosa* (Brid.) Nyholm, is welcomed. Two more fascicles are planned to complete this

work of merit; the last, probably rather small, will include the Tetraphidales, Polytrichales, Andreaeales, and Sphagnales.—According to a letter from the author, fascicle 4 was printed in 1960 but was not available for distribution until March or April of 1961.—H. CRUM.

SEVILLE FLOWERS: *The Hepaticae of Utah.* University of Utah Biological Series 12(2): 1-89. Pl. 1-18. Fig. 1-26. 1961. ($3.00.)—Utah, like several neighboring states, is no bryological paradise. Because collecting is too "scroungy" and discouraging in a limited variety of arid habitats, only a devoted bryologist is likely to find more than a fraction of the total flora, or even to try! Dr. Flowers has slowly accumulated specimens and data, over a period of 35 years, for 60 species and one variety of hepatics from the state and has presented the flora in a manual form with keys, descriptions, and excellent illustrations. An introductory essay on morphology is admirably suited for teaching purposes anywhere in North America, and because the genera and most of the species are common and widespread elsewhere in North America, this manual will find use far beyond the political confines of Utah. Highly recommended!—H. CRUM.

LEO F. KOCH: *Bryology.* Scholar's Library Bibliographic Series, [2] + 20 pp. Scholar's Library, New York. 1961. (Spiral-bound, photo-offset, $1.25.)—This is an unsorted list of 347 titles without annotation. It is, of course, a useful contribution and has great merit. Its defects are obvious. A bibliography classified as to subject matter (taxonomy, distribution, ecology, cytology, economic uses, etc.) would have been infinitely more useful to bryologists and non-specialists alike. Explanatory notes would have justified the inclusion of some titles not obviously bryological (such as Ahti's paper on caribou lichen stands in Newfoundland). The inclusion of some titles of lesser importance "if they appeared in less well known, and not so readily available journals" might also be criticized in the light of some very striking omissions—Bridel's *Methodus,* Schwaegrichen's supplements to the *Species Muscorum,* Müller's *Synopsis,* and Warnstorf's *Sphagnologia Universalis,* to mention a few works of basic importance. Extensive floristic and taxonomic contributions by Renauld and Cardot and Bartram, for example, are missing. The second edition of Conard's *How to Know the Mosses,* a great improvement over the first, is not cited. Many misspellings (Kikobia, Billing, Gyorphy, Bontanical, Renaudl) and the absence of most accents on foreign words shake one's confidence in the accuracy of dates and pagination. Buy this book by all means, but use it with discretion.—H. CRUM.

WINONA H. WELCH: *A Monograph of the Fontinalaceae.* viii + 357 pp. Fig. 1-35. Martinius Nijhof, The Hague. (1960) 1961. (Cloth: guilders 38.—..)—Since 1934, when she published her monograph of the North American Fontinalaceae in Grout's *Moss Flora,* Dr. Welch has been the recognized authority on this most difficult of all moss families, noted not only for the extreme variation associated with aquatic or subaquatic habitats but also for a lack of clear-cut and tangible characters. It is a pleasure to note the completion of a world monograph, prepared with the diligence and care for which the author is well known. Three genera are included in the treatment: *Fontinalis* (20 species and nine varieties), *Brachelyma* (two species), and *Dichelyma* (four species). (*Wardia, Hydropogon,* and *Hydropogonella* were removed from the family earlier by the same author.) Each species or variety is described in great detail and illustrated, with lengthy citations of specimens examined. Curators who wish to annotate

their specimens will welcome the index of collections cited, some 70 pages listing collectors by name and date and the taxa to which the specimens are assigned. The index to published exsiccati is similarly useful. I have already found this book very useful and have gained the impression that it is a sensible treatment of a group which has until now been my despair! The book is handsomely produced and does credit to the author's long labors of nearly 30 years.—The date of publication is acutally January 26, 1961.—HOWARD CRUM.

EGBERT H. WALKER: *A Bibliography of Eastern Asiatic Botany. Supplement* I. xl + 552 pp. 2 maps. American Institute of Biological Sciences, Washington, D. C. December 1960. (Cloth: $18.50, $16.50 to AIBS members and non-industrial libraries).—The original bibliography to eastern Asiatic botany is so well known as a standard reference work that it serves as a strong recommendation for this supplement covering the years from 1936 through 1958. References, freely annotated and cross-indexed, appear alphabetically by author and also by subject and locality. Lichens are also treated separately on pp. 491-493 and bryophytes on pp. 493-498; under both headings papers are indexed according to general, geographic, and systematic entries. Inclusion of Chinese and Japanese scripts for authors' names and titles published in oriental languages is not only a bibliographic nicety (meritorious in itself), but it also makes this work much more useful to oriental students. Librarians will find the character-stoke indices invaluable in reference work. Original Russian appears in transliteration; all other languages, except French and German, are generally presented in translation. This book, printed on an excellent and durable grade of paper, is strongly bound for hard usage.—HOWARD CRUM.

RECENT LITERATURE ON LICHENS—39[1]

WILLIAM L. CULBERSON[2]

ASAHINA, Y. Lichen vegetation of Ozegahara Moor and its vicinities. Pp. 537-538 *in* Y. Ogura (editor), ["Scientific Researches of the Ozegahara Moor."] xvi + 841 pp. Tokyo. 1954. [About 80 spp.]

———. Lichenologische Notizen (§170-172). Jour. Jap. Bot. 36(2): 46-50. 4 fig. 1961. [New: *Stereocaulon hokkaidense* Asahina & Lamb n. sp.]

———. Lichenologische Notizen (§173). *Ibid.* 36(3): 65-67. 2 fig. 1961. [New: *Leciophysma japonicum* n. sp.]

———. Lichenologische Notizen (§174-179). *Ibid.* 36(7): 225-232. 8 fig. 1961. [New: *Stereocaulon dendroides* n. sp.]

———. Lichenologische Notizen (§180-181). *Ibid.* 36(8): 257-262. [misspaged as "225-230."] 3 fig. 1961. [New: *Parmelia* (Xanthoparmelia) *seto-maritima* n. sp. Notes on *Sticta wrightii* Tuck.]

———. Lichenologische Notizen (§182-184). *Ibid.* 36(9): 289-291. 2 fig. 1961. [On *Parmelia subtinctoria* Zahlbr., *P. subcrinita* Nyl. and *P. sanctae-crucis* Vain.]

BRODO, I. M. A study of lichen ecology in central Long Island, New York. Amer. Midland Natural. 65(2): 290-310. 3 fig. 6 tab. 1961. [A study of epiphytic lichens.]

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[1] Names and titles transliterated and translated respectively from the Russian.

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CHADEFAUD, M. Traité de Botanique Systématique. Tome I. Les Végétaux Non Vasculaires (Cryptogamie). xv + 1018 pp. 713 fig. Masson & Cie Editeurs. Paris. 1960. [Lichenology: pp. 531-536, 620-643. Bryology: pp. 905-972.]

HALE, M. E. JR. Lichen Handbook, A Guide to the Lichens of Eastern North America. x + 178 pp. 58 fig. 20 pl. 3 tab. Publication 4434. Smithsonian Institution. Washington, D. C. 1961. Price: $4.00. [Introduction to lichenology; keys to macrolichens. Reviewed in this issue of *The Bryologist.*]

[KIRA, T.] [Deciduous-conifer Forest.] 36 pp. 6 fig. [Association for Forest Technology. Tokyo.] 1950. [In Japanese. Popular notes on lichens in northwestern Manchuria, p. 36.]

KOBAYASI, Y. An imperfect lichen found in the Antarctica. Spec. Publ. from the Seto Marine Biol. Lab. [Sirahama, Wakayama-ken, Japan], Biol. Results of the Japanese. Antarctic Res. Expedition. No. 13. 7 pp. 4 fig. 1961. [The sp. is not identified.]

[KUROKAWA, S.] [Places receiving the "Kryptogamae Exsiccatae" in Japan.] Misc. Bryol. et Lichenol., No. 16: 5-6. 1958. [In Japanese.]

[———.] [Second lichen collecting trip to Mt. Fuji.] *Ibid.* No. 16: 6-7. 1958. [About 30 taxa. In Japanese.]

KUROKAWA, S. *Anaptychiae* (lichens) and their allies of Japan (6). Jour. Jap. Bot. 36(2): 51-56. Fig. 14-16. 1961. [New: *A. neoleucomelaena* n. sp. with f. *sorediosa* (Jatta) n. c. et n. stat., v. *squarrosa* (Vain.) n. c. et n. stat.; *A. lutescens* n. sp.]

LU, DING-AN. [Notes on Chinese lichens. 1. *Peltigera.*] Acta Phytotaxonom. Sinica 7(3): 263-269. 1 fig. 1958. [5 spp. New: *P. polydactyla* v. *dolichospora* n. v. In Chinese, English summary.]

MANNING, S. A. New, rare and critical Norfolk lichens (1). Trans. Norfolk & Norwich Natural. Soc. 19(2): 65-68. 1960. [20 taxa, none new.]

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NÁDVORNÍK, J. Příspěvky k lišejníkovému rodu *Lecidea* (Ach.) Th. Fr. v ČSSR. [Beiträge zur Flechtengattung *Lecidea* (Ach.) Th. Fr. in der Tschechoslowakei.] Preslia 33: 308-314. 1961. [About 50 spp. New: *L. acrocyanea* v. *lutescens* n. v., *L. cyathoides* v. *percruenta* n. v., *L. fuscoatra* f. *expallens* n. f., *L. carpatica* f. *pycnocarpoides* n. f., *L. latypizella* n. sp., *L. platycarpiza* v. *oxydata* n. v., *L. sarcogynella* n. sp., *L. somphoteroides* n. sp.]

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SALO, MAIJA-LIISA. Lignin studies. II. The lignin content properties of lignin in different materials. Maataloustieteellinen Aikakauskirja 29: 202-210. 3 tab. 1957. [*Cladonia alpestris* contains a small amount of a lignin-like compound.]

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———. Range of the Japanese lichens (VI). *Ibid.* 11: 53-62. Fig. 42-46. 1960. [On *Usnea diffracta* Vain., *Parmelia caperata* (L.) Ach., *P. ulophyllodes* (Vain.) Sav., *Solorina crocea* (L.) Ach., *S. platycarpa* Hue, and *S. saccata* (L.) Ach.]

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[———.] [Catalogus Lichenum japonicorum (ed. 2).] *Ibid.* 2(6): 89-92; 2(7): 107-108. 1961. [Alphabetic checklist, continued. *Cladonia degenerans* through *Coccocarpia*. Title and author's name do not appear on these installments.]

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NEWS AND NOTES

Recent deaths: A. LeRoy Andrews (Nov. 1, 1961), T. C. Frye (April 5, 1962), A. W. Herre (Jan. 16, 1962), Theodor Herzog (May 6, 1961), Mario Jäggli (Dec. 27, 1959), Leslie Jenkins (Dec. 11, 1961), Mauno J. Kotilainen (April 16, 1961), James Kucyniak (March 11, 1962), J.-A. Lachmann (May 1, 1961), Eugene Moxley (June 6, 1961), S. K. Pandé (in 1960), R. Potier de la Varde (April 19, 1961), Hermann Reimers (May 1, 1961).

The herbarium and library of the late Theodor Herzog were willed to the Friedrich Schiller University at Jena.

Winona H. Welch was made an honorary member of ABS at the annual meeting in Indiana (1961).

Herbert A. Sierk of MacMurray College has been awarded an NSF science faculty fellowship for Ph.D. research on *Leptogium* at the University of Wisconsin.

Charles D. Bird has been appointed Assistant Professor of Botany at the University of Alberta, effective in the summer of 1962. His herbarium will be donated to the University.

The University of Michigan Biological Station near Pellston, Mich., will hold its 54th session from June 25 to August 18, 1962. Aaron J. Sharp will again teach courses in bryophytes and lichens. For information on other courses and research opportunities, inquire of Dr. A. H. Stockard, Dept. of Zoology, University of Michigan, Ann Arbor.

In July 1961 the Smithsonian Institution announced publication of Mason E. Hale's *Lichen Handbook: A Guide to the Lichens of Eastern North America*. This semi-popular introduction treats the morphology and reproduction of lichens and summarizes recent advances in the physiology and chemistry of the group. Keys to more than 200 species are included. Orders (accompanied by $4.00) should be addressed to the Publications Distribution Section, Editorial and Publications Division, Smithsonian Institution, Washington 25, D. C.

In May 1961 Syo Kurokawa arrived at the Smithsonian Institution to spend a year working on tropical Parmelias with Mason Hale. They left in August for six-weeks study in European herbaria.

Fr. Conan Taylor spent two weeks at the Smithsonian last summer working on a lichen flora of Ohio.

The Histology of British Mosses, by J. Else and L. B. C. Trotter, consisting of drawings of 208 species, was recently published in three microfilm strips by Micro Methods, Ltd., East Ardsley, Wakefield, Yorkshire.

The annual meeting of the American Bryological Society will be held at Corvallis, Oregon, during the last week in August 1962. The pre-meeting foray promises to be an exciting experience for bryologists and lichenologists. Preliminary plans call for a day in the "dripping spruce-hemlock forests," as well as exploration of parts of the Columbia River Gorge and a western bog. Faith Mackaness, Anne Bohlen, and Kenneth Wagner are organizing the foray.

Dr. C. EDMUND B. BONNER visited the U. S. from May to October 1961 and made his headquarters at Miami University, Oxford, O. The purpose of his visit was to work with H. A. MILLER on Pacific Island Lejeuneaceae and to promote better relations between the Conservatoire et Jardin Botanique, Geneva, and American herbaria. He visited over 30 botanical institutions across the U. S. and attended the annual foray and meetings of the American Bryological Society. Other distinguished visitors to the U. S. recently include Dr. JERZY SZWEYKOWSKI of Poland (working on new techniques in taxonomy with Dr. MILDRED MATHIAS, University of California at Los Angeles) and Dr. WOLFGANG MAASS formerly of the University of Tübingen (working on *Sphagna* of the maritime provinces and on tissue culture of spruce at Dalhousie University). Dr. W. D. MARGADANT (formerly of the Netherlands) has recently taken up residence in Pittsburgh; he is now at the Hunt Botanical Laboratory.

Dr. OTTO EMERY JENNINGS received an honorary Doctor of Science degree from the Carnegie Institute of Technology Oct. 10, 1961.

Dr. MARGARET FULFORD left on a trip to Patagonia at the end of January 1962.

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THE HEPATIC EXCHANGE

Beginning January 1, 1939, this Exchange has been operated under the same rules as The Moss Exchange. Privileges are available only to members of the American Bryological Society who have paid annual dues of 25c to MR. HARRY WILLIAMS, Millbrook, Ont., Canada. Only fully determined specimens in packets with complete data will be accepted. It is suggested that there be at least five packets of each species with an extra which will be forwarded to the Curator of Hepatics for the American Bryological Society Hepatic Herbarium. All material for determination should be sent to the Curator of Hepatics, DR. MARGARET FULFORD, Department of Botany, University of Cincinnati, Cincinnati, Ohio.

THE MOSS EXCHANGE

As announced in THE BRYOLOGIST **38**: 100, Sept.-Oct., 1935, there is now an exchange for mosses. This exchange is available to members of the American Bryological Society upon payment of annual dues of 25c to DR. RONALD A. PURSELL, School of Forestry, University of Pennsylvania, Mont Alto Branch, Mont Alto, Pa. Only fully identified specimens in packets with complete data on them should be sent in. It is suggested that there be five or more packets of each species.

These two exchanges offer an excellent opportunity for A.B.S. members to build up their own herbaria of choice, well-labelled specimens.